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RECENT PROGRESS IN CHEMICAL TECHNOLOGY.

BY SAMUEL P. SADTLER, PH.D.,
Professor of Chemistry in the Institute.

[*An introductory lecture to the Chemical Course at the Franklin Institute, 1893-94.*]

It having fallen to my lot as Professor of Chemistry in this time-honored Institute to open the course of chemical lectures for the season of 1893–94 the question presents itself at the outset as to how the subject should be taken up. This question is not difficult of solution if we first determine what bearing the science of chemistry has upon the fundamental aims and purposes of the Institute. We have clearly stated in the official title of the Institute the fact that it is constituted for the "Promotion of the Mechanic Arts." Obviously then it is essentially chemistry as applied in the arts that we should concern ourselves with. A thorough grounding in the principles and theories of the science

as preparatory to this study of its applications might be included in this field to be occupied by the Institute if her means and facilities allowed of it. But for the present, and until the Institute can boast of those newer quarters and larger resources that her friends have been hoping for, she will have to content herself with endeavoring to fill in a narrower sense the object of her organization.

Looking at the specific relations of chemistry to the mechanic arts, therefore, it has seemed to me desirable to open the series of chemical lectures with a "Review of Recent Progress in Chemical Technology."

In the production of the metals, the most notable advances made in recent years are those which concern the light metals, aluminum, magnesium and sodium, and these advances have been largely coincident and connected with the great improvements in applications of electricity. Thus, until the issue of the Grætzel patents in 1883, aluminum was manufactured solely by the Deville process, at Salindres, France, and later at Oldbury, near Birmingham, England, under Webster's patents. In 1885, the Cowles electric process was made public and has continued in use to the present time. Heroult's process, also an electrical one, was patented in 1887, and is at present being worked on a large scale, both in Switzerland and France. Hall's process, patented in 1889, and Minet's, which is practically identical with Hall's, however, represent the most successful applications of the electrolytic method to the production of the metal aluminum. So it has come about that the Aluminum Company, of Oldbury, England, although it has cheapened the price of sodium under Castner's patents and controls Webster's improvements on Deville's process is unable to make aluminum in competition with the electrolytic methods and has retired from that field. In this country and in England, the two processes now in use are those of Hall and Cowles, while on the Continent, the Heroult and the Minet processes are followed.

The production of aluminum in 1892 was as follows: In the United States, 133,779 kilos; by the Aluminium Industrie Actien-Gesellschaft, at Neuhausen, in Switzerland, 286,100

kilos; and by the Société Electro-Metallurgique Française, Isère, France, 60,000 kilos. The English production I have not seen stated.

At the Columbian Exposition the raw materials and the products of the aluminum industry were very satisfactorily shown by the Pittsburgh Reduction Company, and some individual exhibitors in the galleries of the Mining Building. The beauxite used as the source of the alumina is now mainly supplied from the Alabama and Georgia deposits, which were also well illustrated in this connection.

As the Aluminum Company, of Oldbury, England, as just stated, have had to retire from the competition with the electrolytic processes, they have devoted themselves to the production of sodium and, in looking for new utilizations for the metal, have brought out sodium peroxide as a commercial product. This has already found a large sale for wool and silk-bleaching and other purposes for which hydrogen peroxide has been used. As compared with barium peroxide and hydrogen peroxide (10 volume solution) it contains available oxygen as follows:

	Available Oxygen. Per Cent.
93 per cent. sodium peroxide	19·5
91 per cent. barium peroxide	8·6
10 volume solution hydrogen peroxide	1·6

It is made, according to Castner's patent, by treating metallic sodium contained in aluminum vessels at a temperature of 300° C. to the gradual oxidizing action of a mixture of oxygen and nitrogen in which the proportion of oxygen is gradually increased. This is done in an iron pipe which passes through the furnace and along which a current of air is passed from one end. The vessels containing the sodium pass along the entire length of the pipe, the sodium being oxidized at first by air which has almost been deprived of its oxygen, the proportion of the latter gradually increasing until it is finally oxidized by air containing the full amount of oxygen. The product is a yellowish white partially powdered substance, which dissolves in water with considerable evolution of heat. It may be used to develop hydrogen peroxide just as the barium peroxide

is used, or used direct with the addition of a magnesium salt in order to convert it into the magnesium peroxide, the alkalinity of the sodium peroxide when taken alone being injurious.

In turning to the metallurgy of the heavier metals, there are improvements capable of being discussed in the case of many of them, but for the purposes of this review we will have to choose only the most prominent for mention. The one which has certainly attracted the most attention on the part of chemists is the so-called "cyanide process" for the extraction of gold and silver from their ores. While the fact of the solubility of gold and silver in cyanide of potassium solution has been known for years and applied in electro-metallurgical processes, the application of this solvent power of the cyanide for the extraction of the finely disseminated metal from the ore has only been made in the last few years. The process has been applied in the United States under the patents of Simpson and others and on a larger scale in the South African gold fields under the patents of MacArthur and Forrest. The process as applied to gold ores is in outline as follows: The damp tailings are charged into wooden vats of a capacity of fifty to seventy-five tons and the vats filled to within a few inches of the top. Cyanide solution of 0·6 to 0·8 per cent. strength is then allowed to flow into the tank until it is completely filled. This solution is allowed to remain undisturbed in contact with the ore for twelve hours. Each vat is provided with a false bottom covered with some straining material, usually cocoanut matting. Below this is a layer of coarse sand and pebbles, through which the solution percolates. An iron pipe communicating with the vat below the false bottom takes the filtered solution to the "zinc boxes," when precipitation takes place. As the liquor is drawn off during the leaching process, it is replaced by fresh solution. This operation is continued from six to twelve hours, according to the value of the tailings. At the end of this period, which is known as the "strong solution leaching," a weaker solution (containing 0·2 to 0·4 per cent. of cyanide) is turned on and allowed

to filter through the ore for about eight to ten hours. When this is drawn off a quantity of wash-water about equivalent to the moisture originally contained by the ore is run in and the weak cyanide solution so displaced. The amount of cyanide solution used is about half a ton of strong and half a ton of weak solution for every ton of ore treated. This part of the process has been modified by pumping back the solution as it filtered through the bottom of the vat and so keeping up a circulation of the original solution for some thirty-six hours. The extraction of gold by this circulation system was equal to that obtained by the ordinary method and the consumption of cyanide was much less. The cyanide solution carrying the gold dissolved now goes through wooden troughs, commonly known as "zinc boxes," where shavings of zinc cause the deposition of the gold as a finely divided black slime upon their surface. After passing the "zinc box," the "exhausted solution," which should not retain more than a trace of gold, flows into a storage tank to be pumped back to the leaching tanks when a fresh charge has to be treated. Very great loss of cyanide takes place by secondary decomposition of the potassium salt, due to the galvanic action of the gold-zinc couple that is formed. The slime of finely divided gold and silver with a large proportion of zinc and lead and smaller amounts of tin, antimony and accidental impurities after thorough settling and transferred to enamelled iron pans and carefully dried. It is then mixed with sand, borax, and bicarbonate of soda and melted in a crucible yielding a bullion about 650 fine.

In the Molloy process, which is said to be in successful operation in South Africa, the use of zinc is dispensed with altogether. The cyanide solution from the leaching tanks passes through a shallow trough containing mercury, in which is an inner cylindrical vessel filled with solution of carbonate of soda; the edges of the cylinder just dip beneath the mercury so that its contents are entirely cut off from the outer portion of the vessel. A rod of lead dips into the soda solution; the lead and mercury are connected with opposite poles of a battery, and the solution is electro-

lyzed by the passage of a current. The sodium combines with the mercury to form sodium amalgam which at once decomposes the gold cyanide solution with formation of ordinary gold amalgam, sodium cyanide being simultaneously produced. It is claimed that much less decomposition of the cyanide takes place than with zinc, and moreover that the outflowing solution is better adapted for dissolving fresh quantities of gold. In the ordinary method a large accumulation of zinc in the solution must take place, which in time renders them valueless for gold extraction whereas sodium cyanide is just as effective as the potassium compound.

Turning now to the acid and alkali industries not much of fundamental importance is to be noted in the former. At the Columbian Exposition were shown in the exhibit of Heræus, of Hanau in Germany, large platinum stills of the Faure and Kessler system, in which the interior of the still was plated throughout with gold. It has been found that this surface of gold will stand the action of concentrated sulphuric acid much longer than one of platinum. I have since seen two such stills in operation in a large chemical works and understand that the claim is thoroughly borne out in practice.

Perhaps the most important matter of interest in connection with the alkali industry, is the attempt now being made by numerous experimenters to accomplish a commercially successful electrolysis of salt solution with chlorine and caustic soda as the products. The results, with two of the most prominent processes (the Greenwood and the Le Sueur) were summed up some months ago by Messrs. Cross and Bevan, of London, England, and from their article (*Jour. Soc. Chem. Ind.*, 1892, p. 963) we shall quote. The chief difficulties met with were the devising of a diaphragm of such low resistance as would allow the electrolysis to proceed with a reasonable low electro-motive force, and which would at the same time effectually prevent the recombination of the products of electrolyzer; and the construction of an anode which would stand wear and tear. In the Greenwood process, "the electrolysis consists of a rectangular

tank of slate or other suitable material divided into compartments by means of diaphragms. These are made of a number of V-shaped shelves of glass or slate placed in a mahogany frame. The spaces between the shelves are filled with asbestos. On one side of the diaphragm is the cathode made of iron and on the other side is the anode. This is of peculiar construction, being built up of a number of pieces, of hard retort carbon cemented together by first impregnating with tar and subsequently heating to a high temperature. The inside is filled with type metal. The cathodes and anodes in every electrolyzer are connected together in parallel circuit, the electrolyzers themselves being in series. Arrangements are made by means of pipes for allowing the salt solution, which is about half-saturated, to flow through all the anode and cathode sections, respectively. The chlorine which is evolved passes into the chlorine main. The caustic solution after passing through a sufficient number of electrolyzers is evaporated, and the excess of undecomposed salt removed." In the Le Sueur process, the electrolyzers consist of an iron tank fitted with a sloping floor on which rests the cathode. This is formed of a ring of iron filled with several pieces of iron wire gauze. Several small holes are drilled in the top part of the ring to allow of the easy escape of the hydrogen. The diaphragm, which rests upon the cathode, consists of two parts, a sheet of ordinary parchment paper, and a double sheet of asbestos cemented together by means of coagulated blood albumen. The anode consists of pieces of ordinary retort carbon imbedded in a mass of lead through which electrical contact is obtained. In this process the diaphragms have to be renewed every forty-eight hours, and the carbon anodes in from six to eight weeks. When the electrolysis has been continued long enough for the solution of caustic to reach a strength of about ten per cent. the liquor is run away, and the alkali precipitated as bicarbonate. The Le Sueur process is now in operation at Rumford Falls, Me., on a scale of three tons of bleach per day. E. Hermite and A. Dubosc (*Zeitsch. für Angew. Chem.*, 1892, p. 729) claim that all these attempts at simple electrolysis of salt solutions will

remain unsatisfactory, because the heat of the combination of sodium and oxygen is less than that of sodium and chlorine, so that a current of sufficient electro-motive force to decompose sodium chloride will also decompose the sodium oxide as fast as formed. Thus the electro-motive force used is practically wasted. They have proposed and patented two methods for preventing this. The first is to cause the sodium oxide in the moment of its formation to enter into combination to form a sodium salt possessing a higher heat of chemical union than sodium chloride, so that the electro-motive force of the current may remain constant. Such a compound they find in sodium aluminate, which will form if pure gelatinous alumina be present in the salt solution undergoing electrolysis. As soon as all the alkaline chloride is decomposed, the current is stopped, and carbon dioxide is led into the solution when the alumina hydrate is again set free while sodium carbonate is formed. Their other proposal is to use as cathode plates of amalgamated copper or other metal over which a thin layer of mercury is continuously made to pass. As the alkali metal separates out, it is amalgamated, and this sodium amalgam is, by a special device, removed promptly into another receptacle where it is decomposed by water, with the formation of caustic soda solution.

I am not aware that these proposed processes are as yet carried out on a practical scale. Cross and Bevan, however, state that the original Hermite process for the continued electrolysis of magnesium chloride solutions for bleaching purposes is proving highly successful on the continent of Europe, and that it is now replacing 3,000 tons of bleaching powder per annum.

While the two great products sought to be obtained in all of these processes above described are chlorine and caustic soda, it must not be overlooked that these are side products. In the solution will be found hypochlorites and chlorates also. In connection with the Greenwood process it has been proposed to extract the latter salt.

An entirely different utilization has, however, been proposed for weak electrolyzed brine solutions, depending upon

the development of hypochlorites therein. I refer to their use as disinfecting agents. The Woolf process, as taken up for experiment by the New York City Board of Health, proposes to disinfect large quantities of liquid sewage by adding to it weak electrolyzed brine solutions, and it is stated by Dr. Cyrus S. Edson to have accomplished very remarkable results in the experiments made under his direction in New York.

In the class of nitrated mixtures for explosive purposes there has been much published and patented in the last few years. The improvements have been mainly in two lines, viz: smokeless powders and high explosives which combine safety of transport and handling with great energy of decomposition. The former are largely mixtures of nitro-cellulose and nitro-lignin (both soluble and insoluble varieties) with alkaline or alkaline-earth nitrates. A very interesting series of analyses of such smokeless powders, by Prof. C. E. Munroe, formerly of the United States Naval Torpedo Station, at Newport, will be found in the January number of the *Journal of the American Chemical Society*. The second class include mainly mixtures of substances very rich in oxygen, whether solid or liquid, and highly condensed carbon compounds. To these belong the series of Sprengel explosives, rack-a-rock (chlorate of potash and nitro-benzene) and similar compounds. These can be mixed frequently on the spot just before use, and so safety of transport insured as the compounds taken singly are inexplosive or in some cases peculiar detonating fuses are needed to develop their explosive power.

Very great interest has attached in recent years to the discovery of large and valuable deposits of native phosphates of value in the manufacture of fertilizers, but as a special lecture on this subject by a gentleman who has had exceptional opportunities of studying these deposits, will follow later in the course, I will leave the matter, feeling that it will be thoroughly discussed at that time. Similarly the cement industry and especially the manufacture of Portland cement, which has made great advances in the United States in the last few years, will be left for a special lecturer

to follow later in the winter, a gentleman engaged himself in the manufacture of cement, and by the newest and most improved methods. A lecture is also down on our list on the subject of "Emery and other Abrasives." In this will doubtless be mentioned the very interesting new compound, known by the trade name of "carborundum." By heating together a mixture of 100 parts of sand, twenty-five parts of salt and twenty-five parts coke in an electrical furnace for several hours is formed along with graphite a new and interesting chemical compound SiC (silicon carbide), to which the trade name of "carborundum" has been given. This forms crystals of a greenish-gray color of the hexagonal system, of specific gravity 3·22, and of a hardness little if any inferior to the diamond. A full account of the discovery and properties of this interesting compound by the discoverer, Mr. Ed. G. Acheson, will be found in the September and October numbers of the *Journal of the Franklin Institute.*

Turning now to the organic side of Chemical Technology, and beginning with the subject of petroleum and mineral oils, we may notice the interesting results of Professor Engler, of Carlsruhe, of which he presented a brief abstract in a paper read before the Chemical Congress at Chicago, in August last. He finds that almost all the animal fats and fatty oils when distilled under strong pressure yield hydrocarbons of the paraffin series. Besides the oil some water and combustible gas was always formed. By fractional distillation the oils yielded gasoline, benzine, illuminating and lubricating oils and even paraffine wax. Samples of all these prepared from train oil were shown in connection with the reading of his paper. The bearing of all this on our theories of the formation of petroleum is very important. Many prominent geologists have expressed the view that the origin of petroleum was to be sought in marine animal life, of which we find the mineral remains in the oil-bearing strata. Engler first distilled quantities of salt-water fishes and shells under strong pressure, but only obtained a mixture of nitrogenous bases, such as pyridine, bearing no relation to petroleum. But, as before said, the results were very different with train and fish oils. He therefore

believes that while the easily decomposable nitrogenous material of marine animal life has disappeared, the accumulated fatty oils and blubber under the pressure of sedimentary strata, and aided perhaps by heat, have undergone destructive distillation with petroleum as the main products.

A new class of products of considerable practical interest derived from the class of semi-drying oils, like cotton-seed and rape-seed oils, is that known as "blown oils." These are produced by heating the oils to a temperature of about 200° C. for some hours while a current of air is forced through them by a blowing machine. The changes effected are quite marked. Thus, while common cotton-seed oil has a specific gravity of 0·925 and a very moderate viscosity, after the blowing operation is complete its specific gravity is raised to 0·960 and the viscosity is raised in an extraordinary degree. Moreover the thorough oxidation thus effected has improved its character as an ingredient in lubricating oils in other respects. It is no longer liable to acidity when used as a lubricant, and so is especially adapted for mixing with paraffin oils for the manufacture of the best heavy lubricating oils. Numerous other uses have also been found for these blown oils, such as the manufacture of artificial leather and other products.

In the domain of the essential oils, very important discoveries have been made in the identification of the essential odoriferous constituents of several of the essential oils and the consequent synthetic preparation of these constituents. It has been established that the esters of certain alcohols of the composition $C_{10}H_{18}O$ and $C^{10}H_{20}O$ are the principal constituents of a large number of essential oils which owe their aroma in the main to the esters in question. Thus, for instance, linalyl-acetate and other esters of linalool, $C_{10}H_{18}O$, have been recognized as constituents of lavender oil, bergamot oil and petitgrain oil, while geranium oil, lavender oil and lemon-grass oil contain esters of geraniol, $C_{10}H_{18}O$, principally geranyl-acetate. In pine oils finally esters of borneol, $C_{10}H_{18}O$, have been found. It is similarly found that citral, $C_{10}H_{16}O$, the aldehyde of geraniol is the main constituent of oil of lemon and that

rhodinal, $C_{10}H_{18}O$, is the fluid constituent of oil of rose. All of these compounds of definite composition are now prepared in a pure state and are coming into use in the perfumery trade as much more reliable than the natural oils themselves.

Another interesting class of products closely related to those just spoken of are the so-called "ester-gums," recently offered to the varnish trade as substitutes for copal, dammar, mastic, sandarac and other natural varnish gums. These ester gums are the glyceryl, methyl and ethyl esters of abietic and pinic acids and are prepared by saponifying ordinary colophony resin (or common rosin) under pressure and then freeing the ester so formed from water, etc., by distillation in vacuo. The artificial gums so obtained are soluble in all the varnish-forming solvents and form varnish films of great brilliancy and durability.

In a lecture which I delivered here in January, 1892, I spoke of the chemistry of starch and the decomposition products obtained from it under the influence of the diastase of malt. The importance of the industries based upon starch and its alteration products makes this a subject of practical as well as theoretical interest. Dr. Lintner, of Munich, has recently published the results of studies made by him on this action of diastase. He considers the existence of the complicated dextrine molecules of high molecular weight, described by Brown and Morris (an account of which was given in the lecture before referred to) as very unlikely. By the aid of phenyl-hydrazine as reagent, Lintner established the presence of isomaltose as an invariable ingredient in the product of the diastatic action. By the use of four different methods of study, viz: the determination of specific rotatory power, the reducing power of Fehling's solution, the molecular weight determination, according to Raoult's method, and the addition of phenyl-hydrazine as reagent, Lintner determines that five well-characterized products can be obtained from the action of diastase on starch. These are the three dextrines already known under the names of amylo-dextrine, erythro-dextrine, and achroo-dextrine, isomaltose and maltose. Supported upon the results of the

molecular weight determination, Lintner gives to amylo-dextrine the formula $(C_{12}H_{20}O_{10})_{54}$; to erythro-dextrine the formula $(C_{12}H_{20}O_{10})_{18}$; and to achroo-dextrine $(C_{10}H_{26}O_{10})_5$. Brown and Morris' complex dextrines he considers to have been mixtures of these simpler dextrines with either isomaltose or maltose, as all five products of the diastatic action may exist together in the infusion at the same time.

The chemistry of cellulose and its derivatives has attracted the attention of many experimenters. Among the most important results have been those of Cross and Bevan on the new forms of cellulose obtained from what they term cellulose sodium xanthate. This is formed by treating the cellulose with a concentrated solution of sodium hydrate, and exposing this product to the action of carbon disulphide vapor. Action ensues, and in the course of an hour or two a yellowish mass is obtained, which swells up enormously on treatment with water, and finally dissolves completely. This crude solution containing yellow bye-products, yields the cellulose derivative in a pure state on treating it with saturated brine or with strong alcohol. These precipitate it either in a flocculent condition or in leathery masses which may be washed with sodium chloride solution or sixty-five per cent. alcohol, respectively. On re-dissolving in water, an almost colorless solution of extraordinary viscosity is obtained. A seven per cent. solution of the compound, *i. e.*, containing (say) five per cent. of cellulose to 100 of water has a viscosity equal to that of glycerin measured by the rate of flow. The solutions of this cellulose-sodium xanthate undergo decomposition, however, spontaneously after a time, more rapidly by heating or the addition of reagents. There separates out then a firm coagulum of hydrated cellulose, easily capable of purifying by simple washing with water. The spontaneous gelatinization of the solutions appears to take place without change of volume, the coagulum invariably reproducing the details of the surface of the containing vessel. Shrinkage then ensues, the form of the coagulum being perfectly retained. Solutions exceeding ten per cent. strength (in cellulose) give a coagulum of great solidity; even when diluted to 0·5 per cent. strength the

cellulose jelly obtained has sufficient consistency to be handled. Among the many applications of the solution or of the pure cellulose separating from it, may be mentioned the following, which have been pointed out by the authors:

(1) As an adhesive substance, replacing glue, flour-paste, gums, india-rubber solution, etc.

(2) For sizing and filling textiles. In this direction the important advantage of depositing a substance of the same chemical composition and physical properties of the textile does not need to be insisted upon. The authors in this way have introduced from fifteen to thirty per cent. of additional cellulose without the possibility of its presence being appreciated except by comparison with the unfilled fabric.

(3) For purposes of producing casts and moulds. By coating surfaces with the solution or filling hollow vessels, perfect reproduction of form and structural details can be obtained in the form of a more or less solid mass of cellulose hydrate. The cellulose when fully de-hydrated by drying, forms a transparent mass, resembling horn, which can be worked in the lathe, taking a brilliant surface under cutting and polishing tools.

(4) The applications of the various forms of the solid cellulose in block or film form are evident to any one who has followed the utilizations of celluloid or nitro-cellulose, over which this has the advantage of lack of dangerous inflammability.

One of the industries in which great changes have been made in the last few years, owing to the introduction of new chemical processes, is the tanning and leather industry. While the tanning of heavy leather has been improved by the widespread introduction of oak and hemlock bark extracts of definite and uniform composition, it is in the tanning of lighter leathers, such as calf and kid, that the greatest advances have been made. For these, the "dongola" tanning and the newer "chrome" or mineral tanning processes have almost entirely displaced older methods. The dongola process is a combination process using gambier, alum and salt together in the same liquor and following the tanning proper by a treatment of the

leather with "fat liquor," or oil emulsified with borax or soda solution.

It is, however, the successful introduction of the mineral tanning processes which is now revolutionizing the manufacture of lighter leathers in this country. The process generally in use at present involves treating the skins at first with a weak solution of bichromate of potash, to which sufficient hydrochloric acid is added to liberate the chromic acid. After the skins have taken up a bright yellow color through their entire texture, they are drained and transferred to a bath of hyposulphite of soda, to which some acid is added to liberate sulphurous acid, which reduces the chromic acid to green chrome oxide, while the sulphurous acid is at the same time oxidized to sulphuric acid, which liberates a further portion of sulphurous acid until the whole of the chromic acid is reduced. The leather so produced is of a pale bluish-green color, tough and flexible, and thoroughly resistant to water. Indeed, it is this latter property which distinguishes it from all other forms of leather, as the combination of the hide fibre or coriin with the chromium oxide is apparently more stable than its combination with tannin, and yields less to boiling water. The leather also can be dyed and produced in a variety of colors, but the dyeing must be done before the leather dries, as its water-repellent character is such that once dried it cannot be wetted sufficiently to take up a full color. The process is now carried out in this city at several morocco tanneries on a very large scale, and with perfectly satisfactory results.

Chrome-tanning processes involving the use of chrome alum and other salts of the sesquioxide of chromium as the basis of the tanning vat have been used, but apparently the combination does not take place so readily as where the chromium oxide is obtained in *statu nascendi* by reduction from the bichromate under the influence of reducing agents. Basic chromium salts have also been recently proposed as mineral tanning agents, but of their practical success I cannot speak from personal knowledge. That mineral tanned leather has taken a strong hold upon the industry was made evident by the many and fine exhibits of such leather

at the recent Columbian Exposition, and can also be gathered from the testimony of foreign experts who visited this country during the past summer. Prof. Henry Procter, of the Yorkshire College, Leeds, England, in a lecture delivered since his return, says of the chrome process that "it may be said to be the most striking new departure in tanning which has taken place within my memory."

With this brief and partial survey of the field I will conclude, simply drawing attention to the fact that we will have the pleasure this winter, in our course of lectures, of hearing several of their subjects taken up in detail by eminent specialists.

THE LUMIÈRE-LIPPMANN COLOR PHOTOGRAPHY.

BY F. E. IVES.

[*Read at the stated meeting of the Institute, held Wednesday, Nov. 15, 1893.*

In the spring of 1892, there were exhibited in the Photographic Exhibition in the Champ de Mars, in Paris, photographs, by the Lippmann process, of a parrot, a branch of holly, pieces of colored glass, etc., which M. Alphonse Berget and others declared were true reproductions of the colors of the objects. I could see in these photographs only the colors of thin films, metallic and changeable as such colors usually are, and in some instances not even confined to the colored objects themselves, but spreading over objects that were uncolored in the original. These pictures were also devoid of either whites or blacks, the high lights of the objects being rendered more like blacks than the shadows. Others, notably Mr. Cameron Swan, who wrote a letter on the subject to the *London Times*, noticed the same defects in these photographs, and Captain Abney, who had experimented with the process, found that by varying the time of exposure he was able to make a blue photograph with red light, and *vice versa*, and a colored photograph with white light. It was generally admitted that the results obtained by Profes-

sor Lippmann did not sustain the claims made for the process; and when it was announced, this year, that the brothers Lumière had succeeded in so far improving upon Lippmann's method as to obtain really satisfactory color photographs of natural landscapes, those who had seen the photographs for which such extravagant and inaccurate claims were made a year before, were naturally and very justly skeptical.

Now, however, the Lumière photographs have been shown in London, and although there is still a certain amount of mystery surrounding them, it is possible to form a truer estimate of their character and importance, and to make an intelligent comparison with another and more successful method based upon quite different scientific principles.

The Lumière photographs are about three inches square, and by light reflected from their surface at most angles, they have much the same appearance as the French albumen process lantern positives, the high lights of the picture looking like clear glass and the shadows having the appearance of an albumen or gelatine film filled up with a dense, dark-colored deposit of silver. It is said that by transparency they are negative images; but those shown are sealed up so that they cannot be examined by transmitted light.

Unlike Lippmann's photographs, these examples show color only when the light is reflected from the surface at one particular angle, and for that reason the colors are not "changeable." This in itself is really a very important improvement, although it carries us further away from, instead of nearer to, the popularly desired conditions in color photography. It is, indeed, a significant fact that real and undoubted improvement intensifies instead of lessening a characteristic defect of the original Lippmann photographs, which some writers have not hesitated to say would "undoubtedly" be overcome, namely, the inability to see the colors at all angles.

If the pictures were uncovered the critical angle would undoubtedly be perpendicular to the surface of the plate; but it would then be necessary to provide some means for

illumination and vision in precisely the same direction. It is also necessary that the source of light be large enough to illuminate the entire surface of the photograph equally with parallel rays coming from it. A rough approximation to these conditions is secured by covering the picture with a shallow prism, and then examining it by the reflected light of a sufficient exposure of even white or gray sky, holding the picture at nearly arm's length away from the eye. More satisfactory results could doubtless be obtained by means of a special device, which could be used like the stereoscope or photochromoscope. It would be quite easy in this way to exactly fulfil the theoretical requirements for illumination and vision, and at the same time to magnify the picture, which must now be made to occupy only a very small angle of vision in order to be seen all at once.

The pictures are also projected upon a screen by means of the megascope or aphengescope lantern, and in the absence of a special device for examining them by daylight, this is the only really satisfactory way of seeing them. It is, however, necessary to employ a powerful electric arc light in order to project them with satisfactory brilliancy up to even two feet diameter, as compared with ten feet or twenty-five times greater area, for the photochromoscope pictures with the same light.

Seven pictures were shown at the Photographic Congress, and at the Camera Club: four landscapes, two portraits with accessories, and one reproduction of a chromo-lithograph, a rather poor result, the original of which was not shown. Unlike Lippmann's photographs, they rendered the deepest shadows black, and the high lights white, and showed many delicate shades of color which impressed the spectators as being something more than the ordinary colors of thin films. One of the landscapes was beautiful, although the foliage appeared to be that of autumn, and it was understood that the photographs were made in early summer. In parts of some, the chlorophyl green was fairly well represented, but in others, where autumn foliage was not suggested, the green was raw and metallic. The red of a tile roof looked dull and faded, the blues of the skies were criti-

cised by some of the spectators, and the flesh in the portraits had an unnatural purplish hue; but in my opinion these defects are only such as one ought to expect, from the manner in which the process was carried out, even assuming that it be really capable of making accurate color reproductions if carried out in a thoroughly rational manner. From a theoretical point of view (and it follows, from a practical point of view,) it is not reasonable to expect that a mixed color like chlorophyl green will be accurately reproduced on a plate not sensitive into the red of the spectrum below the first absorption band of chlorophyl or which is disproportionately sensitive to that red as compared to the sensitiveness to green. In the first case, the green rays only would act in producing the picture, resulting in a raw, metallic color, and in the other case the red rays would act too much, or the green too little, and result in a brown or red hue, suggestive of autumn tints. Flesh color, if the plate be disproportionately sensitive to blue, and not sufficiently corrected by yellow screen, must take on a purplish hue, or if over-corrected by yellow screen, a yellow hue must result. It follows that the plates must not only be sensitive to all colors, but the sensitiveness must also be properly distributed along the spectrum, or, what amounts to the same thing, must be modified by the use of a quantitatively selective color screen, made up and adjusted by experiment in photographing the spectrum itself, just as I have for years made selective color screens for carrying out the photochromoscope process and for orthochromatic photography until the spectrum photographs correspond to the spectrum itself in the relative visual intensity of the different colors. Until this is done, it is not reasonable to expect that delicate shades of compound colors will be accurately reproduced by any process. It would appear from this that by no evident possibility can this method ever possess any advantage over the photochromoscope process in the matter of accuracy, because in both cases it depends (admitting every possibility for the Lumière-Lippmann process) upon the relation of sensitive plates and color screens, which must be regulated in the same way for both processes.

One of the most remarkable things about this Lumière process is its rendering of blacks and whites. According to Lippmann's theory, the blacks should be rendered by clear glass, and the whites by a film filled up with laminæ of deposit which would reflect light of every wave length. In short, the greatest amounts of deposit and opacity would be in the whites of the picture, and the smallest amounts in the blacks, as in an ordinary photographic negative. I have already observed that the Lumière photographs when seen by ordinary reflection resemble a positive instead of a negative. It is further remarkable that the greatest amount of light reflected from these photographs comes from the parts which look like clear glass, and that even this amount, which makes the whites of the picture, is only equal to the reflection from a black glass, or the surface of the gelatine film itself. The shadows appear black, not because there is no deposit there (in which case the deepest shadows of the picture would be as "white" as the high lights in the examples shown), but because the glass is obscured by a deposit so heavy and matt that it scatters the light striking upon it, instead of reflecting it straight back at the critical angle. In other words, we appear to have a positive where we are told that there is a negative; if this be true, is the positive the result of a "reversal" of the image by the long exposure, and, if so, is this reversal one of the conditions of success?

Does not this image built up by photographic action upon the sensitive plate act by a process of substraction from the white light, which would otherwise be reflected from all parts of its surface alike, instead of by reflection from internal laminæ in the manner assumed by Lippmann?

Lippmann's theory, as I understand it, calls for a different series of laminæ within the film for every wave length of light, amounting, where white light acts, to over 30,000 laminæ in a film no thicker than a single wave length of red light! Would not such a series of laminæ reflect a great deal of light instead of adding nothing whatever to the normal reflection from its surface, which is all we appear to have in the examples shown? Cannot every color actually

shown in the Lumière photographs be reproduced by means of a single interference film of varying thickness, backed up and broken by a granular deposit of varying density? Have we anything more than this in the Lumière photographs?

It seems reasonable to suppose that the long exposure given to these plates would produce a reversal of the image. The dense deposit in the shadows might result from the action of scattered light in the camera, or to preliminary exposure, or to the use of a too active developer, or to any or all of these causes combined. May we not be given an opportunity to learn the truth, in order either to prove Lippmann's theory, or to formulate a new and more rational one?

At first glance, it would appear that an examination of the Lumière photographs by transmitted light might yield an answer to all of my questions, by showing that the image is really a negative one; but it is not even necessary, in order to explain the "whites" of these pictures, to assume that the image is positive throughout, but only that there is a superficial reversal, just sufficient to prevent the production in development of a deposit superficial enough to obscure the normal surface reflection of the gelatine film.

I have some hesitation in putting forth views which a more thorough examination of the Lumière photographs might lead me to modify; but since such examination is forbidden, I can only hope that the questions which I raise may help to bring about such a thorough investigation of the subject as its importance demands.

In conclusion, it is worthy of note that the Lumière-Lippmann process, whatever its capabilities as to accuracy may prove to be, when it is carried out according to theoretical requirements, is necessarily subject to limitations similar to, and in some respects greater than, the already successful photochromoscope process. which is carried out with commercial sensitive plates and ordinary development. Knowledge of this fact, which cannot be gainsaid, will doubtless lead many people to take an active interest in the friendly rivalry which promises to attend the further development and application of the two methods.

A PLEA FOR THE STUDY OF ELEMENTARY FORESTRY IN THE LOWER SCHOOLS.

By Edwin J. Houston, Ph.D.

[*A lecture delivered before the Franklin Institute, November 3, 1893.*]

Members of the Institute, Ladies and Gentlemen:

It is with no little hesitation that I advocate what at first sight may seem to necessitate the introduction of an additional study into the curricula of our lower schools. Already these curricula are overcrowded. So many studies are demanded of our younger children that their minds are bewildered as they are necessarily hurried from one subject to another. Before new ideas have sufficient time to develop they are disturbed and displaced by disconnected and not infrequently irrelative ideas so that neither become factors in the child's mental development.

The tendency of the best methods of education is to simplify and unify these studies; not to increase their number. Unless, therefore, I can show that such introduction is along these lines I acknowledge that my proposition is unwise. But I believe I can show that my proposition to introduce the study of forestry into the lower schools does not necessarily tend to increase the number of studies, but rather to unify existing studies. The present is a time of marked advance in educational methods. The incorrect or utterly bad methods of the past are rapidly being replaced by more correct and advanced methods, and the educational future appears bright and promising.

But I think that in this as in all reform movements there is a danger to be apprehended. We should take time to make haste slowly. In all reform movements besides the true reformers there are invariably to be found many who insist on associating themselves with the movement without exactly comprehending its significance. Such people delight

in posing as reformers. Seeing old ideas or methods attacked it is sufficient, in their misguided judgment, for a thing to be old to place it among the things needing reform. It never appears to enter into the minds of such would-be reformers to enquire whether the thing they desire to reform has any element of good in it. To them the fact that it is old, is sufficient to stamp it as bad and needing reform.

Such reformers seeing poor results produced in a particular line of work, especially if it be in their own line, are apt to ascribe the failure to any other cause than to faulty performance. It never seems to occur to them that the fault may lie in themselves. They look for it rather in a faulty system or in any but the true cause and, therefore, clamor for a reform of the system when they should honestly labor to reform their manner of applying the system.

I think this is especially true in the reform movement in educational matters that has accomplished so much good and that promises to do so much in the near future. The past few decades have unquestionably witnessed marked improvements in educational methods. But along with the good has come much unmitigated evil. Together with the true reformers in this work, whose object has ever been to retain that which is good and to reform only that which is bad, are to be found not a few others who are desirous of reforming everything except themselves. Such would-be reformers, unable to appreciate the inestimable value of those golden educational principles that have required centuries of experience to acquire, have entered into the Holy of Holies in the Temple of Education and have not hesitated to lay their sacrilegious hands on all that comes before them. So many changes have thus unwarrantably been introduced into educational systems as new and improved methods that they threaten, in many respects, to render the new or reformed system less intelligible and practical than the old. Indeed, from my standpoint as a teacher, I think that not a few of the so-called improved methods, recently introduced into our educational systems, are such

unmitigated evils as to call for immediate and complete abolition.

Such a state of affairs is, perhaps, to be expected where the necessary reforms have been far- and wide-reaching. The educational methods of our forefathers, and indeed, the methods existing in the school days of those I have the honor of addressing, I think all will acknowledge, contained many things that sadly needed improvement; but, I feel sure I can confidently appeal to your judgment as intelligent people, whether there was not also in these old methods, much that has unfortunately been swept away in the false portion of the reform movement, which could profitably be re-established.

I repeat, therefore, that, appreciating as I do, the extent to which the false and worthless have been introduced into our educational systems under the guise of reform, I feel no little hesitation in placing myself in the position of advocating what may at first sight seem to be, and what to a certain extent is, the introduction not only of an additional study into the curicula of our lower schools, but also of a study of so difficult a nature as forestry.

I believe, however, I can convince you that though the study of elementary forestry be introduced into our lower schools, yet considering its necessarily limited scope there would not thereby be necessitated so much, the introduction of a new study, as a better and more logical distribution of the studies already established.

I would recommend the introduction of forestry as a branch of elementary natural science. Fortunately, there is no need at the present time for an extended plea as to the wisdom of introducing science studies into even the lowest of our schools. It is so generally acknowledged that natural science possesses marked educational values that I think the wisdom of introducing it early in the school course will be readily conceded.

For my part, I believe that science studies should not only have a place in the earliest portions of the child's school work, but that they should form the bulk of such work. I will state somewhat in detail my reasons for this belief.

because I feel that if I can establish this principle beyond a peradventure, I will have gone far towards justifying my plea for the introduction of the elementary study of forestry early in the school work.

For general purposes of classification, I would arrange the studies suitable for the first year of the child's school work under the three general heads of Natural Science, Language and Number.

Did I desire to make a still broader classification I would make natural science the basic study in the first years of the child's school life, and language and number branches of science studies rather than separate studies.

My reasons for such an arrangement are as follows: I believe that nearly all the child's early schooling should consist in teaching it carefully to observe what is happening around it. Such happenings must necessarily consist mainly in ordinary natural phenomena, the causes and effects of which can only be intelligently studied under natural science. I do not care especially what particular branch of natural science is taken as the starting point. I believe that to be the best system of primary education which attempts to develop the child's mind from observations made by the child itself; which, instead of attempting to instruct the child by repeated statements of glittering generalities, leads it to observe the things around it and to ask questions concerning their causes and effects. Such a method makes the object of its studies the things which actually come under observation by its senses; *i. e.*, things it can actually see, handle, smell or taste, rather than abstract things of which it can generally form no definite ideas.

I would give the child its earliest lessons in language from descriptions of the natural objects it has observed, teaching it carefully to describe, in its own language, the impressions or ideas which such observations have produced on its mind, guiding and directing, to whatever extent may be necessary, the language with which it clothes such ideas. According to this method in the first part of a child's school work, language would not be made a study

separate and distinct in itself, but merely a branch of that basic study—natural science.

I would, in a similar manner, teach the primary ideas of number; never attempting to deal with abstract ideas, but invariably employing actual things the child observes, and preferably things that it can readily handle.

Since the things the child would thus observe, necessarily form portions of the earth's surface, being as they are the various things it sees on the land, in the air, or in the water, I believe that the basic study in primary education should be the study of natural science as centred in and forming a part of elementary geography.

I do not mean by this the geography which I fear is still taught in many of our schools, but the new and properly reformed geography, which I am glad to say is rapidly gaining ground among thoughtful teachers. I would base the child's earliest lessons in geography on its personal observations of natural phenomena; not of phenomena in some distant or remote corner of the earth, inaccessible to the child, but in that exceedingly limited part known to the child from living on it. In other words, I would advocate at the start not the study of the earth as a whole, but the study of that part of the earth which forms the child's home surroundings, or what the Germans call *Heimatskunde*.

I think, however, it would be a mistake to keep the child too long on the study of natural phenomena in the immediate neighborhood of its home. We must not forget that the wonderful recent improvements in methods of transportation and in means of communication, either by the telegraph and telephone, or by the printed page, have made our earth very small; or, if you prefer so to state it, have greatly extended the sphere of home surroundings. The *Heimatskunde*, therefore, so far as geographical studies are concerned, can, very early in the primary course, become the *Erdkunde;* viz., the earth as a whole, and I quite agree with Krapotkin, in his recent admirable address to the Teachers' Guild Conference, at Oxford, that from this stage onwards; viz., through all the remaining grades of the

primary, the secondary and the higher education, the *Heimatskunde* and the *Erdkunde* should in geographical work be carried on in parallel lines.

While I think the primary education of the child should thus be founded on the study of natural science, yet I am aware of the fact that a danger exists in this method, which should be zealously avoided. It is briefly this: Do not permit the child's observations to become disconnected and haphazard. Do not permit the child to accumulate a heterogeneous collection of facts that have no connection whatever. If early scientific information is to possess any value, it must be systematized. For this purpose intelligent supervision of the child's observation will be required, and here an opportunity will be afforded for the best work of the teacher.

So far as the early study of geography is concerned, I believe it to be of great importance to impress on the child's mind the fact that all the observations it is making have a special bearing on the character of the earth's inhabitants. In other words, that just as all natural science tends or should tend to render the life of man more comfortable, happier and better, so all the study of geography tends or should tend to the earth's master—man.

If these facts are constantly kept in mind all elementary work in natural science will of necessity take the form which all truly scientific work must take; viz., a systematized form as opposed to a disjointed and disconnected form.

The methods I would recommend in the study of elementary natural science are, therefore, based on the fundamental principle that the child is to be kept in touch with nature, rather than in contact with books; is to be asked to observe what it can touch, taste, see or hear, rather than to attempt to describe, much less understand, things it never has seen and probably never will see. It is evident that these two things are as different as light is from darkness, and are as widely separated from each other as the east is from the west.

But after the child has for some time studied natural phenomena by means of personal obsérvations on objects

actually seen or handled, there is a means by which its field of observation may profitably be extended to embrace things it can neither actually see nor handle, and this is by bringing them before it through pictures or photographs. Where such pictures or photographs are reliable they may afford great aid to an intelligent child. They can never, however, possess an educational value equal to that of the objects themselves, since mere pictures or photographs must to a great extent fail to possess the vividness of outline and color of the real objects. Pictures and photographs form, indeed, a species of books the use of which it is the very object of the new method of education to escape. They should be employed to supplement the actual things only where the actual things are unattainable. I would, therefore, employ pictures or photographs with care during the early school work and even here, only after the child has performed considerable work without such aid.

The practical teacher should ever be on the alert to lead the child's mind along lines for which it shows a decided preference; provided, of course, such lines appear desirable. In this connection advantage may well be taken to put to use the desire so common in children to make collections. All children possess this desire; and, at some time or other, all will collect. It may be only dirt or mischief, buttons or stamps; but if intelligently directed, this collection may be one or another of the many things which go to make up a natural history collection; minerals, insects, butterflies, flowers, leaves, etc. Start children collecting; and, if you have never tried it before, I am sure you will be agreeably surprised at the intelligent, even enthusiastic, interest you will thus awaken.

If the early lessons in the school room are based on what the child actually observes there will be no lack of interest in its school work. Talk to any intelligent child about simple natural phenomena in such a way as to interest it, and I am mistaken in my experience with children if you will not have a torrent of questions poured into your ears, that will cease rather from your ability or willingness to reply to them, than from the child's stock and trade in such things

being exhausted. Should we not as intelligent people take a hint from this characteristic of childhood, improperly called inquisitiveness, but in reality indicative of a true thirst for knowledge?

A danger exists in all educational work, but especially in the case of younger children, of failing correctly to understand the principles taught. Josh Billings has very aptly remarked, "It is better not to know so much, than to know so many things that ain't so."

This difficulty, so quaintly described by Mr. Billings, is especially liable to occur either when an attempt is made to teach abstract facts to immature minds, or when the teacher is not thoroughly acquainted with the subject.

Apropos of this latter, I remember some time ago a statement in one of the newspapers, which, though intended to laud the teaching of science to young children, nevertheless, to my mind, formed a striking instance of the dangers that sometimes lurk in such teaching. The article cited the case of a teacher, who, during a walk with some children, adroitly led them to ask questions about the telephone and then followed it by a lesson intended to impress broad scientific principles on their minds. This lesson was so full of inaccuracies and misleading statements that it necessarily laid up for some future teacher, the difficult task of removing such ideas. Though I would teach science to young children I would see zealously that the teachers themselves are first thoroughly instructed in what they are expected to teach.

Impressions made during early childhood are the strongest. The child's mind is then highly plastic; its receptivity is at a maximum. Any false teaching at this stage is most difficult afterwards to remove. It is the best of teachers, therefore, that are required for primary work; not tyros in the art, but veterans.

Let us, therefore, along with the University Extension work that is now being so ably carried on, organize means for properly training teachers in such work, not only by means of lectures and laboratory work, but especially by the very means on which we are so insistent in the case of

children; namely, by bringing the teachers into contact with nature rather than with books; or, in other words, by actual instruction in the field.

I am pleased to say that an earnest and intelligent effort is already being made in Philadelphia to remedy this defect, by means of which opportunities are offered to all who wish to render themselves fit to become science teachers.

I think I know the question that has already suggested itself to your minds; namely, How can we reasonably expect that so difficult a study as the science of even elementary forestry can be comprehended by the children in the lower schools, when, as is well known, so many of the principles of the study are difficult of comprehension even by cultivated adult minds? Did any intention on my part exist to recommend teaching these abstract parts of forestry, I acknowledge that there would be thus added another to that already too extended list of studies, so much of the information derived from which would come under the ban of Josh Billings' criticism.

But while there is much in the science of forestry that is abstruse, there is also much that is wonderfully simple. I would, of course, limit the teaching of forestry in the lower schools to these simple portions. The rest should be relegated to the high school, the college, or the university.

I will give in detail a scheme of such study of elementary forestry as I would recommend for the lower schools as soon as I have briefly stated my reasons for believing that this study should be taught at all.

I do not belong to that class of teachers who believe that the strongest argument which can be urged in favor of placing a particular study on the curriculum, is to be found in its practical character; at least, not in schools short of the high school, the college, or the university. To my mind the cultural or disciplinary values of a study are often of far greater importance than its practical value. I believe that the main object of all education can be embraced in teaching the child three things; namely,

(1) How to observe.

(2) How correctly to draw conclusions from what it has observed.

(3) How correctly to express in spoken or written language the conclusions thus drawn.

If in addition to this, a study possesses a practical value, its value must, of course, to that extent be enhanced; but I do not believe that even in this case its main value lies in its practical character.

There is, however, an additional object in education during the child's school life; there are certain social and moral duties, on which, I believe, it is the function of the school to insist; viz., sobriety, honesty, purity, industry and integrity. These should be clearly impressed on the child's mind, not only in the home, but as well in the school; moreover, the child should in addition be taught the duties it owes to the family, to the school and to society in general. The child should be taught briefly the character of the laws of the country in which it lives as well as the character of the laws that govern natural phenomena.

If then it can be shown that in order properly to teach the child such duties, there must be introduced what appears to be an additional study, a valid reason would thereby be established for such introduction; provided, of course, the requirements of such additional study, in point of time, are not too great. I think I can on this ground, with propriety, recommend the introduction of a study of elementary forestry into our lower schools.

It is curious how great is the ignorance or indifference of the general public, as to the character and extent of the effects produced on a country by the removal of its forests.

The many evils which follow in the wake of the destruction of an extended forest cover are thoroughly recognized by thinking people. There is no question as to the general character and the extent of these evils, nor as to the loss of money to the country in which they occur. There can be no doubt that the interests of nearly the entire community demand that the forests should be protected by the enactment of penal laws, but, notwithstanding this necessity, either a stolid indifference or a wicked ignorance on such questions exists on the part of the public.

[*To be continued.*]

PRACTICAL RESULTS ARISING FROM THE USE OF SAFETY DEVICES APPLIED TO MACHINES.

By JOHN H. COOPER.

Much has already been done by the ingenious inventor and the careful manufacturer to prevent accidents to workmen, whose duties require them to be constantly attending to and handling machines.

To state here that a steam boiler, whose overcharge of steam pressure would prove very disastrous were it not supplied with an automatic safety valve, is not news for this journal, nor is it original information to tell of check and relief valves applied to pipes where escape of water from a steam boiler, or where the bursting of pipes and vessels would result from their inoperation or absence. These things have long been used with good results, as invariable as their application.

To the moving cages and platforms of passenger elevators and to all hoisting machines—such dread sources of accident—the application of "safety catches" has been regarded as absolutely necessary; indeed, no first-class "elevator" is now run without means of security against disaster by falling.

In cases where breakage of the machine is imminent from the nature of the work to be done, and the circumstances of use, a serviceable part of the machine is designed to receive, what might be called a safety or a "breaking piece," of trifling cost, which will hold the parts in proper working place during all regular work, but which will yield to unusual strain and give warning of failure.

Instantaneously acting stop-motions, such as are applied to card-making machines, to weaving looms, and the like, for effecting a sudden stoppage of all working parts when the card wire has gone astray, or when the tardy shuttle has failed to pass the web; these are familiar illustrations of means for protecting the machine against serious breakage.

Usually, all parts of the machine itself are designed for harmonious action and for the production of a specific effect; nothing is left to chance. Its whole causation is intentional. If there be any lack, it exists in the region of approach between the machine proper and the operator, who may not always be on the alert. Something is needed to supply the deficiencies of human thought, or watchfulness; to serve as prompter or guard to the human hand, at the point of danger.

We are safe in saying that no machine can be called perfect, if not adapted in every particular to the needs of the operator, since the machine cannot be run without him. He who uses and guides it should have safe and efficient *handles*, so to speak, whereby he may approach and manipulate it safely and effectively, without danger to himself or injury to the machine. It is all very well to say, "beware;" "take care of yourself;" but the cheapest way in the end is to provide the safeguard and thus protect the operator. As new "hands" are coming into mills all the time, who are presumably ignorant of the dangers surrounding them and of the constant care which is necessary to be exercised over their persons at all times, and so may inadvertently meet with accident, it is certainly most important to perfect the safety elements of machines, as well as to enjoin all in observance of the usual plainly written and conspicuously posted rules.

Experience has shown that a great number of accidents is caused through loss of presence of mind by the eagerness of work-people to get through their work expeditiously, under threat of punishment, if they do not. The largest contributions to the list of accidents, it is said, are amputations and maimings of dexter hands, due to this eagerness. If urging must be done, these results call loudly for safeguards and warning mechanism, and the enforcement of stringent rules for safety.

Fortunately, we are not bound by the ancient law of the Hindoos, who wrote: "Under pretext of care for the creature, their authors imposed the fatal principle, that a

man must not address himself to discovery or invention, as Heaven had provided him all things needful."

It is bad enough to have machines breaking down frequently, but the loss of an operative's hand or life is a more serious matter.

"What would one not do to save the life of a fellow-creature, and how heart-rending it is to find ourselves compelled to be an impotent witness of an accident to a human being! Should we not, therefore, adopt all possible precautions to prevent these accidents, often so terrible, which pass unnoticed only on account of the very frequency of their occurrence?"

These words were penned by a committee of the Industrial Society of Mulhouse, in Alsace, which has devoted the past twenty-five years to the invention, application and publication of appliances and apparatus for the prevention of accidents in factories.

The subject is a broad one, possessing commercial as well as humanitarian importance, either phase of which should commend itself to our earnest attention.

A critical investigation of most accidents has proved that they might have been avoided by an early application of means, which in many cases would have been attended with little expense.

Knowing this, it is safe and timely to re-state the warning words which have been formulated by the committee referred to above—"Indifference to such matters is furthermore no longer admissible. It is all the less pardonable, as here, contrary to the circumstances of ordinary life, the rescue is effected without personal danger of any kind"—the writer means to say that the device may be planned in the inventor's study and applied to the machine during the ordinary processes of its building.

After what has been said on the evident necessity of avoiding accidents to workmen, because of the certain threefold loss to the community where they occur, it appears plain enough that to argue the need of such care-taking would be as throwing words away, and whatever may be said for or against the objects of this society, it has

lived to see its labors crowned with success; therefore, we may unhesitatingly ask our readers to consider these matters and to interest themselves also in the invention and application of them wherever they can be of service, remembering ever, that we owe our workmen other things than the wages given to them, as Mr. Dollfus said, a score of years ago, and among these may surely be named absolute personal safety from the moment they enter our factories and service.

The cause of labor is a common cause, and its benefits are reciprocal. Accident to an operative of a machine may result in irreparable damage, as, for instance, the loss of a skilful hand which may be indispensable to an important industry; on the other hand, the evils arising from bad advice or misdirected training may in time, by proper instructions with renewed effort, be entirely overcome, restoring the man to future and to better usefulness, while the hand severed from a good right arm, the obedient instrument of a well-ordered, commanding brain, is lost forever—lost not only to the owner thereof but to his employer and to the community.

If as Bacon says: "Education consists in removing the difficulties of the mind," and we are made many times aware of the expense and effort to accomplish this in our plentitude of technical schools established among us, believing that we will realize great gain from them, may we not expect advantages by efforts made towards persona safety in the use of machines, not only by giving instructions how to avoid being injured while using them, but in the application of accident-preventing devices, or what is better, to so construct mechanism that accidents to the machine and to the man may be reduced to the least possible number?

With the exercise of ingenuity and care for protecting the machine against injury to itself, the attendant may be protected also, and if proper safeguards be thrown around a machine, with ordinary care and training that may be given, the attendant can perform all the work necessary about and with the machine, with perfect safety to himself, thus preserving machine and man; while the employer, who

may be held responsible for accidents occurring from exposed machinery which might have been protected at little cost, will have performed his whole duty.

Securing safety to the workman is clearly within the pale of engineering. It is just as commendable and desirable a proceeding as safety in the vehicle, securing immunity from disaster to "myself and family," so to speak, when we travel about home, or go abroad: and what a comforting sense of relief to the mind it is, to know that means are being regularly devised whereby accidents are greatly reduced in number and severity.

Whether American factory operatives are more or less the victims of accidents while running their machines than those of foreign countries is probably not known. It would therefore be interesting and profitable to have some well accredited statistics in this particular, whether the American operator of machines, as compared with his co-workers in other countries, has secured a large immunity from personal injury during service, which we may assume would result from his superior intelligence, independence and capability of care-taking. Indeed, we ought not to be satisfied with our methods until we have thrown the search-light of inquiry upon every running machine in the going of which accident may happen, and possibly a human being mutilated or incapacitated permanently for work.

We should be encouraged in this proceeding from its humanitarian possibilities, because good work has already been done as evidenced by the report about to be given; for the reason, it must be remembered, that profit attends the regularity and continuousness of processes, when not interrupted by the excitements incident to disasters, and for the comfort and confidence enjoyed by all when the liability to accident is removed alike from machine and man.

After this introductory, I need not apologize for offering the following report, just received, upon the results of systematic inspection and the enforcing of means for preventing accidents in factories.

The writer is indebted to M. M. Engel-Gros (President of the Association for Preventing Accidents in Factories, Mulhouse) for the following:

Note on the statistics of accidents in Alsace-Lorraine, taken from the official reports of the Imperial Insurance Office of the Empire of Germany, for the year 1887.

The Association of Mulhouse for the Prevention of Accidents in factories has been in existence nearly twenty-five years. It is indisputable that the inspections to which it submits the affiliated establishments have borne their fruits. It is recognized that many accidents, notably the gravest, have become less frequent, and we are agreed in saying that about fifty per cent. of the accidents have been avoided. But it is difficult to estimate, by means of figures furnished by the statistics, the positive results of the inspection, in order to form an idea, as exact as possible, of the number of accidents which have been prevented. Such an estimate is possible only by a comparison of the statistics of Alsace with those of other similar industrial countries in which the prevention of accidents has not yet been applied.

It is these statistics which have been wanting until now. When one seeks in effect to estimate the number of accidents occurring in an industrial region, one meets with many and great difficulties. There exists in many works, notably those which concern insurance against accidents, reports which have served to draw some conclusions. Some have been gathered in the hospitals, others have been collected by researches made in the establishments, or near insurance companies; the Association of Mulhouse from its foundation, has published each year a report of the accidents which have been brought to the knowledge of its inspectors, but all these statistics, while they have served to guide and instruct those who have established them, could not be utilized for a serious and comparative study; some, indeed, only mention serious accidents, others confound the most insignificant accidents with those which have brought prolonged or permanent incapacity for work, without its being certain that all cases are mentioned.

The first definite reports in this order of facts have been furnished by the Imperial Insurance Office of the Empire of Germany, which published, in 1890, a very well made *statistique* of the accidents of the year 1887.

This *statistique* is rigorously exact. It does not apply to all the accidents of which the declarations have reached the professional associations—declarations which are more or less conscientiously made for less serious accidents—*but only to those which have entailed incapacity for work for more than thirteen weeks; to those, in a word, which have provoked inquiries and the intervention of professional associations.* This *statistique* is, beside, well made in order to establish a comparison between Alsace and Germany, because in 1887 the influence of the law upon obligatory insurance was scarcely yet felt, while in Alsace the preventive association has been making its inspections for almost twenty years.

Here are the principal indications which may be drawn from this *statistique*.

The number of persons insured in all Germany during the year 1887, 3,861,560; the number of accidents resulting in incapacity for work for more than thirteen weeks, 15,970; that is, 4·14 accidents per 1,000 insured.

In Alsace-Lorraine the proportion is less than in all the industrial countries of Germany.

The number of persons insured in Alsace during the year 1887, 148,221; the number of accidents resulting in incapacity for work for more than thirteen weeks, 440; that is, 2·97 accidents per 1,000 insured, and a difference of 1·17 per 1,000 compared with those in Germany.

Thus, if in all Germany the conditions had been the same as in Alsace; if the precautions had been taken there as in this country, they would have avoided:

$$\frac{3{,}861{,}560 \times 1{\cdot}17}{1{,}000} = 4{,}518 \text{ accidents.}$$

The proportion of 2·97 per cent. applies to all the industries of Alsace and Lorraine; it includes therefore not only the textile industries, but also the industries of iron and steel, mines, buildings, wood-working and of flour mills, etc., of which some have been more dangerous than the textile industry (especially metallurgy and mining), and upon these latter industries the private inspection of the Association of Mulhouse has had no influence.

If we wish to make a still more exact comparison, only the figures which are given for the *statistique* for the textile industry must also be given. (The workshops of construction might be added to that, but the comparison would be less rigorous, because the great establishments only had subscribed to the association up to the time of the enforcing of the law of obligatory insurance.) As out of 1,000 workmen insured in Alsace, 398·1 are occupied in textile industry, this proportion is still sufficient to permit a comparison with other industrial centres.

On the other hand, the influence of the Association of Mulhouse has been exercised especially on accidents to machines, because it is difficult to reduce the number of the accidents due to the slipping of persons, to the fall of objects, to horses and carriages, etc. A rigorous comparison should then include only the accidents caused by certain kinds of machinery in the different countries.

As the above *statistique* does not permit the making of a similar comparison it was necessary to apply to the Imperial Insurance Office at Berlin, which has kindly sent a copy of all the declarations of accidents of more than thirteen weeks of incapacity, for the year of 1887 in the textile industry. As to the number of workmen employed in the different industries, this appears in the *statistique* published by the Imperial Office in 1885. We have extracted from these reports the figures relative to the spinning of cotton and of wool and to power loom weaving, choosing among the declarations all those which concern the accidents occurring to machines employed in spinning and to weaving looms, for the latter only accidents by leaping of shuttles have been taken into consideration.

TABLE I.—Spinning of Cotton and Wool.

Countries.	Number of Establishments.	Number of Workmen.	Number of Workmen per Establishment.	Accidents Occurring to				Accidents Total.
				Beaters, Willows, etc.	Cards.	Spoolers, Flyers, Combing Machines.	Self-acting Ring Throstles.	
				per cent.	*per cent.*	*per cent.*	*per cent.*	*per cent.*
Prussia, ...	710	33,602	47·3	20 = 0·59	73 = 2·17	38 = 1·13	44 = 1·34	175 = 5·21
Saxony, ...	241	18,681	77·5	9 = 0·48	33 = 1·76	23 = 1·23	37 = 1·97	102 = 5·45
Bavaria, ...	100	15,556	155·5	6 = 0·38	9 = 0·58	10 = 0·64	11 = 0·71	36 = 2·31
Wurtemberg, . .	86	6,897	80·2	6 = 0·87	10 = 1·45	9 = 1·30	5 = 0·72	30 = 4·35
Other countries of Germany, . . .	119	8,976	75·4	3 = 0·33	9 = 1·00	6 = 0·66	10 = 1·11	28 = 3·12
Total, ...	1,256	83,712	66·6	44 = 0·52	134 = 1·60	86 = 1·02	107 = 1·27	371 = 4·43
Alsace-Lorraine, .	94	26,011	277·6	4 = 0·15	15 = 0·57	14 = 0·53	17 = 0·65	50 = 1·91

In this branch of the textile industry there have been in Alsace, 1·91 serious accidents per 1,000 workmen insured, while in the rest of Germany there have been 4·43 per cent.; that is, 2·26 times more.

If in the spinning industries of Germany they had taken the same precautions as in Alsace they would have been able to avoid 4·43 — 1·91 = 2·52 per cent. accidents; that is, 210·9 accidents.

According to the *statistique* of the Chamber of Commerce of Mulhouse for the year 1889, there were, at this time in Germany, 4,392,821 spindles for the spinning of cotton and wool, of which 1,348,473 in Alsace, and 3,344,348 in the other regions.

If we compare the number of accidents to these, we find: 111 accidents in Germany per 1,000,000 spindles; 37 accidents in Alsace per 1,000,000 spindles; that is, 0·24 per cent. in Alsace, against 0·50 per cent. in Germany, which makes a difference of 0·26 per cent., or 36·5 accidents which could have been avoided.

TABLE II.—Power-Loom Weaving.

Countries.	Number of Establishments.	Number of Workmen.	Number of Workmen per Establishment.	Accidents by leaping of shuttles and weaving looms.
				per cent.
Prussia,	984	78,815	97·7	39 = 0·49
Saxony,	357	30,365	85·3	19 = 0·62
Bavaria,	64	7,873	123·0	4 = 0·50
Wurtemberg,	39	4,786	122·8	2 = 0·41
Other countries of Germany,	186	20,073	107·9	7 = 0·34
Total,	1,630	141,312	87·0	71 = 0·50
Alsace-Lorraine,	125	20,511	164·0	5 = 0·24

Finally, there has been made a last comparison relative to the seriousness of the accidents occurring. To this end, we have compared for the textile industry the accidents followed by temporary incapacity to work with those which have entailed permanent incapacity (death, permanent incapacity or permanent partial incapacity for work united); that is to say, to those which have had permanent and irreparable results.

These are the results to which we arrive:

TABLE III.

Country.	Accidents having had lasting results.	Accidents which have only brought Temporary Incapacity for Work.	Total.
	per cent.	*per cent.*	
Prussia,	479 = 89·0	59 = 11·0	538
Saxony,	220 = 92·8	17 = 7·2	237
Bavaria,	64 = 88·9	8 = 11·1	72
Wurtemberg,	54 = 94·7	3 = 5·3	57
Other countries of Germany,	80 = 97·6	2 = 2·4	82
Total,	897 = 91·0	89 = 9·0	986
Alsace-Lorraine,	95 = 76·0	30 = 24·0	125

We see that in the textile industry for 100 accidents occurring in Alsace, twenty-four have entailed only tem-

porary incapacity for work, while in Germany there have been nine per cent. of accidents not serious. From this point of view, then, the advantage rests with Alsace.

From all these comparisons we have the encouraging results that the efforts of the Association of Mulhouse have borne their fruits and that they have attained by private effort that which the official regulations alone have not been able to realize elsewhere.

A MIRROR GAUGE.

By Joseph Becker.

The following is a description of my mirror gauge; an instrument for measuring the thickness of any glass mirror without unframing it.

My gauge consists of a piece of plate glass (*Figs. 1, 2* and *3*), having on one face a graduation *O 1*, and on the opposite

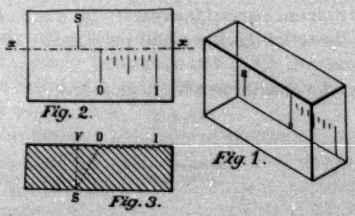

Fig. 2. *Fig. 1.* *Fig. 3.*

face a mark or sight *S*. For reasons to appear further on, the sight *S* is so placed that in the right-angled triangle *S V O* the side *O V* is equal to one-half of the side *V S*.

In use, the gauge is placed (*Fig. 4*) with its graduated face against *B*, the mirror to be measured. Behind the silver backing *C* is formed the virtual image *A'* of the gauge. The observer places his eye so as to catch the ray of light *O S E*; in other words, he places himself so as to see the inner ends of sights *S* and *O* meet and form a line *S O*, the general appearance of the graduations being as indicated in *Fig. 5*.

The observer then reads off the distance $O'\,O$ which is equal to the thickness of the mirror and is, in the case illustrated, five and one-half subdivisions of the scale.

Noting that $O'O$ of *Fig. 5* is simply $O'm'$ of *Fig. 4*, we can formulate the following theory of the instrument.

As both A and B are of glass the line $m'\,N\,O\,S$ is straight, forming similar triangles $m'\,O'\,O$ and $O\,V\,S$. The line $O\,V$

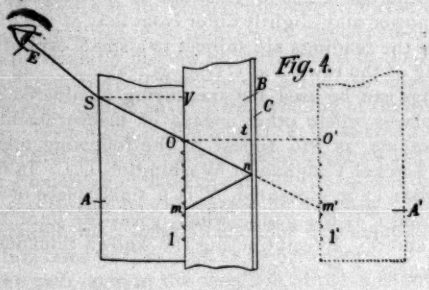

Fig. 4.

we know is half of line $V\,S$, therefore, $m'\,O'$ must be half of line $O'O$, or equal to $O\,t$, the thickness of the mirror.

The general formula giving the thickness x of the mirror is

$$x = O'\,m' \times n\,\frac{S\,V}{2\,V\,O}$$

n being the ratio of the unit of the scale $O\,1$ to the unit of measurement.

Fig. 5.

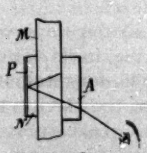

Fig. 6.

The formula reduces itself to the desirable form $x = O'm'$ when the constant factor

$$n\,\frac{S\,V}{2\,V\,O} = 1$$

In the instrument as I prefer to make it, and as I have shown it in *Figs. 1, 2, 3,*

$$n = 1$$

and

$$\frac{S\,V}{2\,V\,O} = 1$$

When different kinds of glass are to be handled, their refractive power may slightly differ from that of the gauge. In this case the readings are subject to a small error due to the bending of the ray $n\,S$ at O (*Fig. 4*).

The gauge can be used for measuring unsilvered plate glass in places where other means of measurement are too troublesome, as will appear in the following method, due to Mr. Samuel Vaughan, of Washington, D. C. In *Fig. 6*, M is the plate to be measured, N is a small piece of looking glass, and P is the gauge which gives the joint thickness of M and N. By subtracting the known thickness of N the thickness of M is found.

WASHINGTON D. C., February 22, 1892.

THE HISTORY AND MODERN DEVELOPMENT OF THE ART OF INTERCHANGEABLE CONSTRUCTION IN MECHANISM.*

BY W F. DURFEE.

[*Continued from vol. cxxxvi, p. 431.*]

Among all the improvements which have combined to make the lathe, in its various forms, the most important of machine tools, for promoting the art of interchangeable construction, the device known as the slide rest is most conspicuous. Like most important inventions, this has more than one claimant.

It is a commonly expressed opinion by writers that the slide-rest was invented by Sir Samuel Bentham, as it is clearly described in his patent of 1793; and there is no

* A paper read before the Mechanical Section of the Engineering Congress, at the World's Columbian Exposition (August, 1893).

doubt whatever but that Henry Maudsley made a tool of that kind while in the employ of Joseph Bramah, in 1794, which was named by his shopmates "Maudsley's go-cart." Joseph Clement is also deserving of great credit as an improver of the slide-rest, in the early part of the present century; but, it is certain that the evidence relative to the ideas embodied in the slide-rest amply justifies the assignment of its origin to France, not only in virtue of the suggestion contained in Bessoni's work already referred to, but, more particularly in view of the fact that in the great Encyclopædia of Diderot there is an elaborate engraving of a "slide-rest" which, anticipates anything of the kind claimed to have been made in England by at least twenty years.

The first lathe for cutting metallic screws was devised by some French watchmaker,* early in the last century, for cutting the thread on the fusees of watches. This lathe is remarkable for a taper attachment quite similar in its idea and functions to that used in modern tools.

The next step in the direction of the modern screw cutting lathe was made in 1775, by Jesse Ramsden, who constructed a small lathe for cutting the "endless screw" or "worm" of his "dividing engine." This lathe had "change wheels" and a tool holder on a slide moved by a "lead screw."

In the year 1816, Richard Roberts, of Manchester, invented the modern form of screw-cutting lathe, and in 1830, a Mr. Parson, of London, invented the swivelling tool post, and in 1831 was awarded the silver medal of the Society of Arts for his ingenuity. Prior to 1828, Joseph Clement invented a surfacing lathe, in which the speed was automatically reduced and the feed automatically regulated as the tool travelled from the centre to the circumference of the work being faced. This lathe was a "gap lathe;" it had flat surfaces for the top of its bed, conical bearings for its main spindle, whose "end shake" was taken by a pivot set-screw in an oil-tight box, and was provided with a two-speed

* *Traité de l'Horlogerie mechanique et pratique.* Par Thiout. Paris, 1741. There are several fusee lathes described in this work. These tools were in use several years before the work was published.—W. F. D.

cone pulley, and a slow-speed equivalent to modern "back gear," which could be thrown out at pleasure. It also had a compound "slide-rest."

The invention of the "apron" on the front of the "tool carriage," and the idea of attaching the various feed controlling mechanisms thereto, is believed to have originated with Baxter G. Whitney, of Winchendon, Mass., the well-known inventor of the "gauge lathe," who also devised the first "universal swivelling bearing" for line shafting.

The form of lathe, known as the "turret lathe," which has occupied a very important relation to the manufacture of interchangeable mechanism during the past thirty years, is believed to be of American origin, although no record of any patent can be found, and no one appears to know who designed the first tool of that kind.

So far as ascertained, it seems to have been first made to meet some special emergency and to have been copied with more or less variation from shop to shop, until at last, the Robins & Lawrence Company, of Windsor, Vt., at the request of F. W. Howe, made the first machines that were regularly made for sale. Some of these machines were put at work in the factory of the Savage Firearms Company, about 1860, and one of the first lot made was purchased by the Brown & Sharpe Manufacturing Company, of Providence, R. I., and soon after they commenced to make this tool for the market, and were followed by the Pratt & Whitney Company, of Hartford, Conn. The successors of the Robins & Lawrence Company, the Jones & Lamson Machine Company, of Springfield, Vt., and the other eminent firms named, have doubtless built a large majority of the turret lathes thus far sold. This tool has commended itself to all makers of interchangable mechanism for a large variety of work, and for the special service of manufacturing machine screws, it has been made automatic by Sharpe, of Hartford, Conn., and as its capabilities are carefully studied, its field of usefulness continues to expand.

Lathes for ornamental turning and the decoration of wood, ivory and metal, doubtless originated in France. In Bessoni's work (1578), already referred to, there are two

"swash lathes" shown for turning a variety of intoxicated vases and balusters, which were in that day doubtless regarded as ornamental.

A modification of the lathe which has had a very important influence upon the production of interchangeable work is that known as the "Blanchard lathe." This celebrated tool was patented by Thomas Blanchard, January 20, 1820, and his patent was twice renewed by special act of Congress, for terms of fourteen years, the last renewal being dated January 20, 1848.

If we are to believe all that has been written in commendation of this machine tool, we shall certainly conclude that Blanchard's invention was an original conception and that it is American genius and inventive talent that the world must thank for an idea that conferred upon mechanism, automatic imitative powers, that were wholly unknown before. We have not time to discuss all of the evidence of the erroneous character of this view, but we will note a few of its more conspicuous features. As early as 1772, sixteen years before Blanchard was born, we find in the great French Encyclopædia, an engraving of machinery for turning irregular forms, in which there is a roller operating against a revolving pattern and controlling the movement of the tool in such a way as to produce on the substance being turned a copy of the outlines of the pattern. In Bourgeron's *L'Art de Jeurneus*, published in 1816, we are shown methods of reproducing medallion portraits by automatic machinery, and it is well known that in the latter years of the life of James Watt, he successfully duplicated busts by mechanism of his contriving. In the famous block machinery Brunel, which was put in operation in 1806, a revolving cutter was regulated in its action by a profile plate.

Although the invention of Blanchard was not in its chief elements, entirely original, nevertheless, the combination was sufficiently novel and useful to entitle it to high rank among the more important improvements that have contributed to the perfecting of the art of interchangeable construction.

Grinding machines for the production of flat and cylindri-

cal surfaces by the action of emery or corundum wheels had their origin in America, and have largely augmented the possibility of cheaply producing accurate work in metal. The grinding lathe, as perfected by J. Morton Pool, in 1868, is believed to have been the first apparatus by which long cylindrical rolls could be given automatically and at once, an accurate surface and uniform diameter. So delicate is the action of the very simple mechanism employed that a uniform reduction of diameter of $\frac{1}{20000}$ inch is quite within its powers. The invention and successful operation of this admirable tool has made possible the manufacture of widths of paper unknown and unattainable before.

The success and possibility even of the various grinding lathes and similar machine tools that have been developed in the past twenty years is due to a very simple American invention; the solid emery or corundum wheel, which has ground its way into recognition and universal employment in all the machine shops of the world.

The modification of the lathe, known as the boring machine, probably originated in Germany, for in a work published in Nuremberg, 1662,* there is an engraving of a duplex boring mill, operating upon two musket barrels at the same time, and in a treatise on artillery, published in France in 1647,† there is a vignette, in which a cannon is shown as being bored by a vertical bar.

About the middle of the last century, cannon and pump cylinders, also cylinders for Newcomen engines were bored horizontally in rude boring mills at Carron Iron Works, in Scotland, and in 1769, that celebrated engineer, John Smeaton, designed new boring machinery for these works. It does not appear that this machinery was perfectly satisfactory, as in a proposal from Boulton & Watt to the Carron Iron Company, in 1776, for the construction of an engine *to return the water* to *their water wheels*, Mr. Boulton says: "Mr. Wilkinson has bored us several cylinders almost without error; that of fifty inches diameter, which we have put up at Tip-

* *Theatrum Machinarum novum, et cet.* Per Georgius Andream Bocklerum. 1662.

† *Memoires d'Artillerie.* Par le Sr Surirey de Saint Remy.

ton, does not err the thickness of an old shilling in any part, so you must either improve your method of boring, or we must furnish the cylinder to you." "The thickness of an old shilling" seems to have been regarded as a very satisfactory standard of permissible error in such work 100 years ago. The Mr. Wilkinson spoken of by Mr. Boulton, was John Wilkinson, of Bersham, near Chester, who had invented improvements in boring machinery in 1775. He it was who first moved a cutter head along a boring bar, supported at each end, and as simple as this idea now seems, it was not perceived by such acute men as Smeaton and Boulton and Watt.

The first planing machine of which we have any account is said by Rennie (Buchanan on *Mill Work*), to have been invented by Nicholas Torq, a French clockmaker, in 1751, and to have been actually used in planing the interior of the wrought-iron pump barrels used in the repairs of the machine erected by order of Louis XIV, for the supply of the water works at Versailles.

We are told that the pumps varied in size from 10 inches to 4 feet in diameter, and were from 7 to 10 feet in length, made of wrought-iron staves planed on their edges, before they were assembled and confined with encircling wrought-iron hoops 3 inches wide and $\frac{1}{2}$ inch thick. A pump barrel 10 inches in diameter and 7 feet long was made up of nine staves secured by twelve hoops.

If Rennie's account is correct, M. Torq had a large job for a newly invented machine, of which it is recorded that it did the work in a perfectly satisfactory manner.

I shall not attempt to discuss the question of who was entitled to the credit of first introducing the metal planing machine into England. Claims have been made for Bramah, Fox, Clement, Murray, Roberts and possibly some others. There is little doubt that all the persons named constructed, independent of each other, during the thirty years preceding the year 1820, some form of mechanism for planing metal. The best description we have of any of these early planing machines is of one built by Joseph Clement, in 1825, as an improvement on one constructed by him prior to 1820. In

this machine the bed was 2 feet 8 inches wide and 12 feet long, and was supported upon stationary bearing wheels, 3 feet in diameter and 2 inch face. The bed was moved by two pinions working into two racks on its under side. The planer was driven by a belt 3 inches wide, running upon a pulley 4 feet in diameter. This tool was said to be a practical success, and at the rate of eighteen shillings per square foot of surface planed earned for its owner £10 for each day it was employed.

This machine was no mere experiment, as it is known to have been in regular use in 1863, thirty-eight years after its construction, and nineteen years after the death of its inventor. Another interesting type of planer was built by Benjamin Hicks, of Bolton, about the year 1840.

This was a "pit planer;" the piece operated upon being stationary, and the crosshead and tool moved by two steel belts 3 inches wide, running on pulleys 3 feet in diameter. This planer could plane a piece of work 30 feet long and 9 feet 6 inches wide.

The style of planer, known as the "shaping machine," was invented by the late James Nasmyth (the inventor of the steam hammer) in 1836, it was at first called "Nasmyth's steam arm." It has been greatly improved by Whitworth and other leading tool builders.

The first machine for planing the teeth of wheels in which the action of the tool was regulated by a guide curve, was invented in 1839, by the brothers Glovet.

The vertical planer, or "slotting machine," was doubtless suggested by the mortising machine for wood. Machines of this kind were built by Nasmyth in 1836. America had done its full share in the development and improvement of construction of machine tools of all kinds, and the work of Wm. Sellers & Co., Bement, Miles & Co., Brown & Sharpe, Pratt & Whitney Company, the Putnam Machine Company, Niles Tool Works, and scores of other makers of American machinery is known and honored wherever hammers beat and wheels turn.

The art of wire drawing has been a liberal contributor to the development of the art of interchangeable construc-

tion. The making of wire was originally accomplished by beating the metal into thin strips, then shearing it into strands of a more or less square cross-section, and then hammering these strands until their angles disappeared, and the strands became approximately round.

Until early in the fourteenth century this had been the only method of making wire from remote antiquity, and was probably practised in Egypt in the time of Moses (1450 B. C.) for we are are told in Exodus 39 : 3, that "they did beat the gold into thin plates, and cut it into wires, to work it in the blue, and in the purple, and in the scarlet, and in the fine linen, with cunning work."

This rude method was improved in Germany by the invention of the draw-plate, which was in use in Augsburg as early as 1350. So long as the rounding was accomplished by the hammer, the workmen were called "wire smiths;" but after the invention of drawing they were named "wire drawers" or "wire millers." So slow did improvement travel in the Middle Ages, that wire drawing was not introduced into England until about 200 years after its invention in Germany.

In order to protect and stimulate the manufacture of wire in England, His Majesty King Charles I, in the sixth year of his reign (1631), *absolutely prohibited* the importation of foreign iron wire, and of cards made from the same. This prohibitory act accomplished its intended purpose so well, that eight years thereafter the King prohibited the importation of brass wire. There is abundant evidence that England's infant industries were carefully nurtured by adequate legal protection.

The relation of wire to interchangeable mechanism is very close. The manufacture of pins, needles, wire nails, wood screws, and fish hooks, rests solidly upon a substratum of manufactured wire. English chronicles tell us that the making of "Spanish needles," as the fine sewing needles were formerly designated, was first taught in England by Elias Crowse, a German about the eighth year of Queen Elizabeth; and in Queen Mary's time there was a negro made fine "Spanish needles" in Cheapside, "but would never teach his art to any."

The first stage in the making of the assembling screws of all classes of small machinery, is the making of wire.

Wires have been produced by a combination of mechanical and chemical operations, of a fineness of $\frac{1}{500000}$ inch, and so smooth and uniform as to rival the spider's web for use in micrometers and similar instruments. The process of wire drawing is not confined to products of a circular cross-section, and a great variety of shapes have been made, but the most interesting form is doubtless that known as "pinion wire," from which the pinions and arbors used in watches, were for many years made. Pinion wire was also used in the beginning of the century in the construction of clocks. The preparation of wheels and pinions for clockmakers' use seems to have been at that time a distinct industry; for in Ree's Encyclopædia (1819) we are told that, "Iron-mongers and tool sellers having on sale sets of wheels and arbors with pinions of different numbers ready slit, and also pinion steel wire drawn in proper shape for the teeth of small pinions, of which all clockmakers usually avail themselves, instead of preparing them." Thus early does the interchangeability of the parts of clocks manifest itself.

Another application of the principle of wire drawing was originally introduced in the British Mint by Sir John Barton, for equalizing the thickness of the fillets of gold and silver from which the blanks for the coin were cut. This consists in drawing the "fillet" (after it has been nearly reduced to the proper thickness by rolls) between stationary hardened steel cylinders, one of which is adjustable by mechanism which enables $\frac{1}{1000000}$ inch to be readily appreciated.

The art of drawing tubes of metal through fixed dies is a natural outgrowth of the art of wire drawing, and a further development of this art is exemplified by the manufacture of metallic cartridges, in which we have an admirable illustration of one of the most recent and most important developments of the art of interchangeable construction.

The art of making a cartridge shell of sheet metal originated in France. In the year 1824, M. Cazalet patented

a cartridge of this material, and in 1834, M. Roberts, of Paris, invented a metallic cartridge, in which the fulminate was deposited in an anulus around its base, which was made of a separate piece of metal from the body of the cartridge. The idea of using a metallic cartridge did not attract much attention, until M. Flobert, about 1850, commenced the manufacture of a pistol intended for use for practice at short range. This pistol could only use a small metallic cartridge, charged exclusively with fulminate. Flobert's pistol and ammunition met with considerable favor for its purpose, and doubtless it had a stimulating influence upon the development of the manufacture of metallic cartridges of an improved type.

To Smith & Wesson, of Springfield, Mass., without doubt belongs the credit of making the first metallic cartridge suited to the requirements of actual service in war. In 1854, they patented a form of cartridge that has always been used in the well-known pistol made by this firm.

Since the above date, the idea has been adapted to breech-loading muskets of a large variety of styles, and at the present time, metallic cartridges are made for quick-firing guns of 3-inch calibre.

It is believed that the general system adopted in the manufacture of the modern metallic cartridge is purely American.

The rapidity, accuracy and economy with which they are manufactured, is the result of the perfecting of a large number of special automatic machines, whose work is so exact that any cartridge will fit accurately: that is, will never be too large for, and never more than $\frac{1}{1000}$ inch smaller than, the chamber of the arm in which it is intended to be fired.

The Union Metallic Cartridge Company, of Bridgeport, Conn., which for thirty years was under the skilful management of the late A. C. Hobbs, has been the leader in the development of this industry, and have supplied the principal foreign governments with large quantities of ammunition and cartridge-making machinery, and it is only just to say that the system of manufacturing metallic cartridges,

now regarded as the best throughout the world was brought to its present state of perfection in these works, during their administration by Mr. Hobbs.

The art of cold punching of sheet metal has important collateral relations to the art of interchangeable construction. Perhaps the best exemplifications of the art of punching is furnished by the gold and silver blanks which are punched in the several mints of the world for subsequent coining into money. The weight of these blanks must be uniform for the specific coin for which they are intended, and this can only be insured by extraordinary care in the making of the punches and dies. The flat links of the chains used in the old fusee watches were punched as early as the middle of the last century.

The punch was made of the same contour as the link, and was guided in its work by two conical pins, projecting from its face; these pins entered the holes intended for the rivets which had previously been punched in the sheet steel, from which the links were to be made. The metal was thus guided to its proper position on the die, so that when the punch took effect, the exterior of the resulting link was symmetrical with regard to the rivet holes through it. This principle thus early discovered is of frequent application in all similar operations. The art of punching has, in comparatively recent times, had coupled with it the art of shaping the metal blank into its various forms, immediately after the punching operation is completed; boxes and their covers, "percussion caps," the cups "for metallic cartridges" and the metal bases of "shot shells" are made in this way.

[*To be concluded.*]

THE CHEMICAL SECTION

OF THE

FRANKLIN INSTITUTE.

[*Proceedings of the stated meeting held Tuesday, December 19, 1893.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 19, 1893.

DR. WM. H. GREENE, President, in the chair.

Mr. Boyer proposed for membership the name of Dr. Nelson B. Mayer, 945 North Eighth Street, Philadelphia; the name was referred to the Committee on Admissions.

The Secretary read his annual report which was accepted. The Treasurer also made his annual report, showing cash on hand at the beginning of the year $74.16; receipts during the year, $141; expenditures, $187.64; leaving a balance of $27.52 in the treasury. The Finance Committee audited the Treasurer's account and found it correct.

The Conservator reported that he had on hand a number of volumes of the proceedings of the Section, which, following instructions from the Section, he would dispose of in accordance with his judgment of the best interests of the Section.

Owing to the fact that Prof. E. F. Smith had declined the nomination for President of the Section, on motion it was voted that nominations for President be re-opened.

Dr. D. K. Tuttle and Dr. H. F. Keller were then nominated; the latter gentleman, however, declined, thus leaving Dr. Tuttle the only nominee, when it was voted that nominations be closed. The Secretary was directed to cast the vote of the Section for the following candidates, who were thereupon declared elected to their respective offices:

President,	Dr. D. K. Tuttle.
Vice-Presidents,	Mr. H Pemberton, Jr. Dr. L. B. Hall.
Secretary,	Dr. Wm. C. Day.
Treasurer,	Dr. H. W. Jayne.
Conservator,	Dr. Wm. H. Wahl.

The Secretary was then instructed to cast the ballot of the Section for Dr. S. C. Hooker, Mr. Reuben Haines, and Mr. C. S. Boyer, as members of the Committee on Admissions, to act with the President, Secretary, Treasurer and Conservator as the remaining four members; the candidates were declared elected.

On motion, it was voted that the Secretary notify the Institute to renew the yearly subscriptions to the current journals subscribed for during 1893.

Dr. W. J. Williams submitted for publication a paper embodying the results of his examination of Pemberton's method of phosphoric acid determination. The main points of this paper had already been brought before the Section at the November meeting by Dr. Terne, who read at that time a communication from Dr. Williams. The paper was referred for publication.

Dr. Bruno Terne then read a paper, entitled "Contribution to Pemberton's Volumetric Method for Phosphoric Acid Determination." This paper was the joint production of Dr. Terne and Mr. Francis Bergami.

Mr. Bergami then followed with a contribution, entitled "Comparison of Pemberton's Method of Phosphoric Acid Determination with the Official Method."

Both papers evoked interesting discussion and comment from many of the members present.

Mr. Reuben Haines was prevented by illness from being present to read the two papers from him announced on the program of the meeting. One of them was presented, namely, "Normal Chlorine in Spring Water near Philadelphia." Owing to the lateness of the hour this paper was read by title and referred for publication. The meeting then adjourned.

WM. C. DAY, *Secretary.*

ROBERT A. FISHER.

Robert Andrews Fisher, a member of the Philadelphia family of that name, died quite suddenly on October 6, 1893. He was the son of Jabez M. Fisher and Nancy Andrews, his wife; having been born on December 21, 1832. Miers Fisher, his grandfather, was a distinguished Quaker lawyer of Revolutionary times.

Mr. Fisher was, in the early fifties, the assistant to Prof. John A. Porter, of Yale College, and, at one time, was Professor of Chemistry at Brown University, which conferred upon him an honorary degree. In those days no facilities were offered in this country, to chemists who were desirous of pursuing advanced courses in their science. He, accordingly, went to Europe, studying at Göttingen and at Heidelberg, and, later on, attending lectures in Paris. Upon his return to America, he accepted the chair of chemistry and mineralogy in the University of California, devoting considerable attention, also, to the mining industry then just

developing in the far West. In this direction, in connection with Prof. Samuel W. Johnson, now of New Haven, Conn., his services, as mining expert, were called upon by the Directors of the Richmond mine in Nevada.

During the last fifteen years of his life he was the consulting chemist to several large industrial works in Philadelphia, having been associated with the Pennsylvania Salt Manufacturing Company, in this capacity, during the greater part of this time. The President of this company bears the following testimony to his professional ability:

"Professor Fisher had achieved a high position in his chosen profession of chemistry, having given especial attention to the scientific branch of the art of paper-making, and was considered an authority on all technical and practical questions arising in that particular manufacture. His knowledge, however, was general, and extended largely into the chemical composition of food products and manufactures, and, in this direction, his attainments and clear, concise conclusions rendered his opinions much sought after on all mooted points."

He also devoted much attention to the manufacture of sulphate of alumina from beauxite as well as from other materials, and the number of patents taken out by him bears evidence to his ingenuity and industry. He took an active part, moreover, in the introduction of the sulphite process of paper-making, in the Western States.

Mr. Fisher was a member of the Chemical Section of the Franklin Institute, and also of the American Chemical Society. He was well informed on all the recent advances in his science, particularly in such as relate to the application of chemistry to the industrial arts, and while possessing a keen insight into the important points of many scientific questions, was careful and conservative in his judgment.

Personally, Mr. Fisher was most considerate and courteous in his bearing. He was widely connected in Philadelphia, and endeared himself to many friends. P.

NOTES ON THE EXAMINATION OF BEESWAX.

By Lyman F. Kebler.

[*Read at the stated meeting of the Chemical Section, held Nov. 21, 1893.*]

When the contribution,* entitled "An Examination of Beeswax," by E. G. Parry and P. A. Estcourt, appeared, describing the sophistication of this article in the English market, the writer had nearly completed a communication on the same subject with reference to this country.

The waxes examined, and the results submitted below, were samples sent to this laboratory for the past year from various parts of the country as specimens representing the waxes the dealers had in stock, and it is not more than fair to suppose that the samples submitted for examination were equal, if not superior, to the beeswax in our market.

At first the process of the legally recognized authority was used. After some time a sample which had been rejected was investigated and reported as complying *in toto* with the requirements of the above authority. The writer was ignorant of the rejection of the wax until he had made his report. The wax had been rejected because it was unfit for electrotyping, and must therefore contain an adulterant of some kind, probably "grease" or some fatty substance. The wax was again looked into with the same results. It has since been found by experiment that the impurity could have been detected by using a twenty per cent. solution of sodium hydroxide in place of a fifteen per cent. solution.

The wax was now examined rigidly by the best methods.

In view of the fact that the literature on wax analysis is at best fragmentary and the methods imperfect, and that the object of this contribution is not only to present the condition of wax in our market, but also to make the paper of practical value to analysts, it is desirable to give here a

* Read before the Brit. Pharm. Conference, Nottingham, through the *Am. Drug. and Pharm. Record*, **23**, 158.

résumé of the best methods employed and the references in the literature.

First, let us consider briefly the composition of beeswax. It is a mixture of *myricin*, *cerin* and *cerolein*.

Myricin ($C_{46}H_{92}O_2$), forms the chief constituent of wax. It is insoluble in alcohol and fuses at 64° C.

Cerolein constitutes only from four to five per cent. of the wax, has an acid reaction, and is the constituent to which wax owes its tenacity, odor and color.

Cerotic acid, or cerin ($C_{27}H_{54}O_2$), is not a constant constituent of beeswax.

B. C. Brodie,* in his classic *Untersuchung über die chemische Natur des Wachses*, has shown that cerin consists essentially of a high fatty acid, *i. e.*, cerotic acid, while myricin is the palmetic ether of melissic alcohol. F. Schwalb† and F. Nafzger‡ have shown that wax contains small quantities of acids related to cerotic acid, as melissic acid; also some non-saturated acids of the oleic acid series and some alcohols related to cerylic alcohol, as melissic alcohol. They have also proven it to contain saturated hydrocarbons, such as hentriacontane ($C_{31}H_{64}$) and hyptacosane ($C_{27}H_{50}$).

It was thirty-four years after the composition of beeswax was made known, or the way paved for the introduction of a method, before one was proposed for the examination of this article based on the determination of the free and combined acids, respectively.

The Acid and the Ether Numbers.—These were determined by the well-known method of Hübl§ (not the iodine number), who was the first to apply the method in a practical way. The method is sometimes awarded to Hehner, who translated his results into cerotic acid and palmate of myricle. Hehner‖ applied the method a few months before Hübl

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* 1848, *Ann. Chem.* (Liebig), **67,** 180; *Phil. Trans.*, London, **136,** 147. 1849, *Ann. Chem.* (Liebig), **71,** 144.

† 1884, *Ann. Chem.* (Liebig), **224,** 225.

‡ 1886, *Ibid.*, **235,** 106.

§ 1883, *Dingl. poly. J.*, **249,** 338.

‖ 1883, *Analyst*, **8,** 16.

did, but Becker* was the first to apply the principle of Köttstorfer† to the analysis of beeswax. Hübl's method is recognized as the most elegant, most convenient, as well as the best method for establishing the purity of this article. The method‡ in detail is: heat three or four grams of the wax with twenty cubic centimetres of neutral ninety-five per cent. alcohol, titrate while hot with a semi-normal alcohol solution of potassium hydroxide and phenolphthalein to estimate the acid number; now add twenty cubic centimetres more of the alkaline solution and saponify by boiling the solution briskly with a reflex condenser for one hour, to insure complete saponification. The excess of alkali is then titrated back with semi-normal hydrochloric acid. The number of milligrams of potassium hydroxide required to saturate the free acids of *one gram* of wax is called the "acid number;" that required to decompose the wax ethers, the "ether number."

The acid number varies from nineteen to twenty-one milligrams, the ether number from seventy-three to seventy-six, while their ratio is from 1 : 3·5 to 1 : 3·8. For complete saponification from ninety-two to ninety-seven milligrams of potassium hydroxide are required. After having secured the acid and the ether numbers the quantity of cerotic acid or its equivalent and myricin are easily calculated. Extreme care must be taken in the titration on account of the extraordinarily high molecular weights of both cerotic acid (410) and myricin (676). One cubic centimetre of normal alkali represents 410 milligrams of cerotic acid and 676 milligrams of myricin, respectively.

Determination of the Alcohols.—Unquestionably the alcohols of beeswax belong to the same series, consequently they possess the same chemical properties. Dumas and Stas described an important reaction of the fatty alcohols, viz: the reaction which they give when heated to a moderate temperature with potassium hydroxide. These alcohols

* 1880, *Corr. Bl. Ver. anal Chem.*, **2**, 57; Abst., *Zeit. anal. Chem.*, **19**, 241.

† 1879, *Zeit. anal. Chem.*, **18**, 199 and 431; *Analyst*, **4**, 106.

‡ 1892, H. Röttger, *Chem. Ztg.*, **16**, 1837; *J. Chem. Soc.*, **64**, 351. G. Buchner, *Ibid.*, **16**, 1922; *J. Chem. Soc.*, **64**, 351.

when so treated are converted into the corresponding acid or alkaline salt, and hydrogen is simultaneously disengaged. For example, when melissylic alcohol is distilled with potassium hydroxide the alcohol is decomposed, hydrogen being evolved on the one hand, and potassium melissate formed on the other, recalling a more familiar example where potassium acetate is formed by treating ordinary alcohol in a similar manner. The constituents of wax (not alcohol), are not affected by this treatment, consequently by measuring the volume of hydrogen evolved, from a given weight, the proportion of alcohols can be approximately estimated. C. Hell,* H. Strürcke† and F. Schwalb‡ applied the above reaction to beeswax long before MM. A. and P. Busine,§ but it was these last two investigators who simplified the apparatus and studied the conditions of success. They proceed as follows: melt two to ten grams of the wax in a porcelain dish, mix with an equal weight of pulverized caustic potash, mix the mass again with three or four times its weight of pulverized caustic potash, then introduce the mixture into a flask and heat on a mercury bath to 250° C. for two hours. The reaction begins at 180° C. The volume of hydrogen evolved by one gram of the wax, varies from 53·5 to 57·5 cubic centimetres at 0° C., and 760 millimetres pressure, corresponding to a percentage of melissic alcohol varying from 52·5 to 56·5.

Determination of Hydrocarbons.—The hydrocarbons are determined very readily by treating the residuum of the preceding determination with an appropriate solvent, as ether. In the above residue all the acids of the wax and the alcohols have been transformed into a state of alkaline salts, while the hydrocarbons alone remain intact. Hydrocarbons are found in wax in almost constant quantity, varying from 12·72 to 13·78 per cent.

The writer did not execute the last two operations because the apparatus of M. Dupre was not available.

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* 1884, *Ann. Chem.* (Liebig), **223,** 269; *Chem. Zig.*, **8,** 859.
† 1884, *Ibid.*, **223,** 295; *Chem. Ztg.*, **8,** 860.
‡ 1886, *Ibid.*, **235,** 106.
§ 1890, *Bull. Soc. Chim.* (3), **3,** 567; *Chem. Ztg. Reper.*, **14,** 225.

The Iodine Number.—By treating wax with iodine a new number is obtained which is of considerable value for analytical purposes. This number was determined by the conventional method of Hübl.* The iodine absorbed by the wax being small it was necessary to use a larger quantity of the substance than ordinarily, consequently more chloroform was needed. The method † in detail is: dissolve two grams of the wax in forty cubic centimetres of chloroform in a glass stoppered flask. Add twenty-five cubic centimetres of an iodine solution, containing twenty-five grams of iodine and thirty grams of mercuric chloride dissolved in ninety-five per cent. alcohol and made up to one litre, and shake. Place the flask into a dark closet for three hours, then add fifteen cubic centimetres of a ten per cent. solution of potassium iodide and 100 cubic centimetres of water, finally titrate the free iodine with a standardized solution of sodium thiosulphate. The "iodine number" expresses the per cent. of iodine absorbed by the wax. It is quite essential to carry blank experiments in order to secure reliable results.

The Melting Point.—This is determined as follows: dip the bulb of the thermometer into the sample of melted wax, for an instant. On cooling, the bulb is covered with a film of the wax. Introduce the thermometer into a wide mouth bottle through its perforated cork. The bottle is now hung into a beaker containing water at about 65° C., carefully noting the temperature at the instant a hanging drop is formed; this is taken as the melting point. Other ‡ methods were used but the above method gave concordant results without consuming too much time.

Specific Gravity.§—This was obtained by diluting alcohol so that the wax, previously melted and cooled normally,

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* 1884, *Dingl. poly. J.*, **253,** 281; *J. Chem. Soc.*, **46,** 1435; *Am. Chem. J.*, **6,** 285; *J. Soc. Chem. Ind.*, **3,** 641.

† *U. S. Bull.*, No. **13,** 818.

‡ 1883, Guichard, *Proc. Royal Soc. Ed.*, **106,** 432, 532; *Zeit. anal. Chem.*, **22,** 70. 1884, H. Krüss, *Zeit. f. Instrumentenkunde*, **4,** 32. 1886, C. Reinhardt, *Zeit. anal. Chem.*, **25,** 11. 1887, H. W. Wiley, *J. anal. Chem.*, **1,** 39.

§ 1879, Hager, *Analyst*, **4,** 206.

would float indifferently in it. The specific gravity of the alcohol being identical with that of the floating wax, it is necessary only to secure the specific gravity of the liquid with a picnometer, or a specific gravity spindle, and we have the specific gravity of the wax. The most trustworthy methods employed for securing the specific gravity of fats, waxes, etc., are given in the *U. S. Bull.*, No. **13**, 40–43.

Stearin, Stearic Acid, etc.—Any foreign acid can easily be detected by Hübl's method. Fehling's* method gives an unmistakable turbidity with *one per cent.* of stearic acid, and is executed thus: boil one gram of the wax in a test tube with ten cubic centimetres of eighty per cent. alcohol for a few minutes, allow to cool to 18° or 20° C., filter, to the filtrate add water and shake. If stearic acid is present it separates in flocks on the surface, leaving the underlying fluid nearly clear.

A. H. Allen† gives a method depending on the insolubility of lead stearate in alcohol. Proceed thus: boil the wax for forty minutes with twenty parts of alcohol, cool; the cerolein and some of the stearic acid remain in solution. Filter and treat the filtrate with an alcoholic solution of lead acetate. If a flocculent precipitate of lead stearate is formed, stearic acid is contained in the wax.

F. Jean's‡ method was also tried but proved unreliable, at all events waxes proven to be free from stearic acid by Hübl's and Fehling's methods gave unmistakable evidence of stearic acid.

7·8 centimetres of semi-normal alkali equals one gram of commercial stearic acid.

Stearin may be detected by the methods employed for stearic acid.

Rosin.—E. Donath's§ method, modified by E. Schmidt,‖ was applied in each case, and is executed thus: place five grams of the wax into a flask, add twenty cubic centimetres

* 1858, *Dingl. poly. J.*, **147**, 222; see, also, *Chem. Ztg.*, 1890, **14**, 606.
† *Commercial Organic Analysis*, **2**, 213.
‡ 1891, *Bull. Soc. Chem.* (3), **5**, 3.
§ 1873, *Dingl. poly. J.*, **205**, 131; abst. *Zeit. anal. Chem.*, **12**, 325.
‖ 1877, *Ber.*, **10**, 131, 837; *Zeit. anal. Chem.*, **17**, 509.

of crude nitric acid (specific gravity 1·32), heat the mixture to boiling and keep at this temperature for one minute. Add an equal bulk of cold water, then an excess of ammonia water. With pure wax the alkaline fluid is colored yellow only, but in presence of rosin a deep brown.

Paraffin.—Paraffin is a common adulterant of beeswax. In fact, some samples of wax might more appropriately be reported as adulterated paraffin, for as high as eighty per cent. of this substance has been found mixed with wax in our markets.

There are many methods* for detecting paraffin and its allies, but the process of the United States Pharmacopœia has given the writer results as reliable as any, and is outlined thus: "if five grams of yellow wax be heated in a flask for fifteen minutes with twenty-five cubic centimetres of sulphuric acid to 160° C., and the mixture diluted with water, no wax-like body should separate."

Care, however, must be exercised in applying the test, as has been shown by C. C. Sherrard† and C. M. Morse.‡

The paraffin is estimated by decomposing a portion of the wax with concentrated boiling sulphuric acid, the charred mass cooled, washed with water, dried and extracted with a Soxhlet's apparatus by means of ether. The paraffin hydrocarbons are thus obtained in a fairly pure state.

Japan Wax.—E. Buri§ regards this wax as a mixture of glycerides and not as a dipalmatin.

A number of methods are claimed by their various authors to be efficient in detecting this adulterant in beeswax, but none has proven itself very effective in the writer's hands. The borax‖ and sodium carbonate¶ methods only deserve mention. Experience has shown that it would be better to abandon the borax method also, or at least to be

* See references *U. S. Bull.*, No. **13,** 828; and *Chem. Ztg.*, 1890, **14,** 607.

† 1892, *Proc. Am. Pharm. Assoc.*, **40,** 252.

‡ 1888, Thesis, College Pharm., Mass.

§ 1879, *Arch. d. Pharm.* (3), **14,** 403.

‖ Hager, 1862, *Pharm. Centrhalle*, **3,** 207; 1880, *Dingl. poly. J.*, **238,** 356.

¶ Donath, 1872, *Dingl. poly. J.*, **205,** 137; *Allen's Com. Org. Anal.*, **2, 212.**

extremely cautious in judging from its results, for the separation into layers takes place easier on paper than in the test tube.

Donath's* general reaction for rosin, tallow, stearic acid and vegetable wax gives a valuable indication but is not specific enough. He directs to boil one or two grams of the wax with six or eight cubic centimetres of a concentrated solution (1 to 6) of sodium carbonate for one minute; if an emulsion ensues, which is persistent after the liquid has cooled, the wax, contains one or more of the above adulterants.

Soap.—This adulterant can easily be detected by boiling a small piece of the wax a few minutes with water, cooling, filtering and treating the filtrate with hydrochloric acid. A precipitate indicates the presence of a soap.

Mineral Matters.—Such substances as *kaolin*, *gypsum*, *heavy spar*, *yellow ochre*, *etc.*, are said to be frequently used as adulterants for beeswax, but examinations of late show that the day of such gross sophistication is nearly past. At the present time, adulteration has in many cases become a science.

Starches.—The various starches can easily be detected with the aid of a microscope or by boiling a small piece of the beeswax with a little water, cooling, filtering and to the filtrate adding a few drops of a test solution of iodine. A blue coloration indicates starch.

Above is given a table embodying the results of the analysis of *sixteen* samples of the wax as received, of which *eight* were pure and *eight* adulterated.

Wax No. 1 is placed at the head as a standard, because it is of known purity and is not to be included in the other sixteen samples.

Neither No. 3 nor No. 9 contained any detectable adulterant, yet the ether number is low. Several trials were made, in both cases, to obtain if possible a higher ether number, but without success. Each sample was boiled for

* Donath, 1872, *Dingl. poly. J.*, **205**, 137; *Allen's Com. Org. Anal.*, **2**, 212.

two hours, so that saponification should have been complete; yet the difficulty might lie here, for R. Benedikt and

Serial Number.	Melting Point.	Specific Gravity at 15° C.	Acid Number.	Ether Number.	Total.	Ratio.	Cerotic Acid.	Myricin.	Total.	Ratio.	Iodine Number.	Adulterants.	Description.
1	62·5	0·960	20·30	74·70	95·00	0·268	14·86	80·57	100·43	0·208	8·35	—	Pure Yellow Wax.
2	62·8	0·960	19·60	70·00	89·60	0·280	21·52	84·50	106·02	0·341	9·31	Stearic Acid.	" "
3	63·0	0·960	18·90	65·80	84·00	0·287	13·32	80·57	100·89	0·231	8·50	—	" "
4	63·8	0·962	20·30	77·00	97·30	0·263	14·86	82·95	97·81	0·182	8·71	—	" "
5	64·2	0·962	19·60	73·50	93·10	0·266	14·86	82·95	97·81	0·182	5·67	Paraffin.	Pure Bleached Wax.
6	64·4	0·962	19·60	73·50	93·10	0·266	14·86	82·95	97·81	0·182	7·28	—	" "
7	64·4	0·962	19·60	73·50	93·10	0·266	14·86	82·95	97·81	0·182	6·80	—	" "
8	64·6	0·962	19·60	73·50	93·10	0·266	14·86	82·95	97·81	0·182	6·80	—	" "
9	64·8	0·962	19·60	73·50	93·10	0·266	14·86	82·95	97·81	0·182	6·80	—	" "
10	62·2	0·960	18·90	74·90	93·80	0·252	13·35	76·93	90·28	0·174	12·80	Paraffin, Stearic Acid.	Pure Yellow Wax.
11	63·0	0·960	19·60	73·50	93·10	0·266	14·86	82·95	97·81	0·182	8·50	—	" "
12	63·0	0·960	19·60	73·50	93·10	0·266	14·86	82·95	97·81	0·182	8·50	—	" "
13	62·4	0·960	19·60	73·50	93·10	0·266	14·86	82·95	97·81	0·182	9·65	Stearic Acid.	Manufacturing Wax.
14	62·6	0·960	19·60	73·50	93·10	0·266	14·86	82·95	97·81	0·182	7·00	Paraffin.	Pure Unbleached Wax.
15	63·0	0·960	18·90	71·35	90·25	0·265	14·86	82·95	97·81	0·182	13·10	Paraffin, Rosin.	" "
16	63·6	0·960	20·30	74·20	94·50	0·274	13·83	86·33	100·16	0·238	9·11	Paraffin.	" "
17	62·8	0·960	21·70	81·90	103·61	0·265	14·86	86·57	101·43	0·207	7·42	Probably Japan Wax.	Pure Bleached Wax.
											4·31		

K. Mangold* say that this method is attended with the disadvantage of saponifying some kinds of wax with diffi-

* 1891, *Chem. Ztg.*, **15**, 474.

culty. These investigators base their results on what they call "*aufgeschlossenes Wachs.*"

In view of the facts that some wax saponifies with difficulty, that no adulterant was found and that the remaining data were approximately normal, these waxes claim a position among the unadulterated.

Samples Nos. 2 and 12 contain stearic acid or an equivalent, yet the specific gravity and the melting point conform in each case as nearly to those of pure wax as could be required. How the manufacturer succeeded in doing this is a question for us to solve.

Heintz* has shown that by mixing stearic and palmetic acids in different proportions a melting point, varying from 69°·2 C. to 55°·1 C., can be secured. Was it a mixture of this kind? The writer was unable to decide.

The use of stearic acid, as an adulterant for beeswax, must be of comparatively recent date, for Hassel, who generally enumerates every conceivable adulterant, in his admirable work, does not allude to it, and Allen, in his *Commercial Organic Analysis*, **2**, 213, says it is "less frequently employed than some of the other adulterants."

The above results show, and other recent investigations corroborate it, that stearic acid is employed almost as extensively as any other adulterant.

Rosin was found only in the sample, designated "manufacturing wax."

Indications point to the presence of Japan wax in No. 17, but nothing definite could be ascertained, owing to the present inefficient methods at our disposal.

Below is a table embodying the properties of the various substances employed in adulterating beeswax. A few of the data are those of the writer, but the majority were secured from various sources in literature.†

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* *Ann. der Physik.*, **92**, 588; Dragendorff's *Plant Analysis*, 1884, Eng. ed., p. 15.

† 1882, Dieterich, *Arch. der Pharm.* (3), **20**, 454. 1885, O. Dammer, *Illustriertes Lexicon der Verfälschungen*, etc. 1891, A. and P. Busine, *Bull. Soc. Chim.* (3), **5**, 654. R. Benedikt, *Analyse der Fette und Wachsarten*, *Zweite Auf.*, 311, *et seq.*

Substance.	Melting Point.	15° C. Specific Gravity.	Acids Soluble in Water.	Acid Number.	Ether Number.	Total.	Iodine fixed by 1 Gram of Wax.	Volume of Hydrogen at 0° C. and 760 m.m. pressure given per gram.	Hydrocarbons from 1 Gram of Wax.
Yellow beeswax,	62–64	·961–·964	0–1	19–21	73–76	92–97	8–11	53–57·5	12·5–14·5
Beeswax bleached by various agents,	63–64	·960–·973	0–2	19–23	74–84·89	93–107·7	1·08–11·36	51–57	11–14·30
Cacao butter,	30–33	·945–·982	0	0–3	192–200	192–204	34	—	—
Carnaüba wax,	83–84	·999	0	4–6	75–76	79–82	7–9	73–76	1·6
China wax,	53·5	·970	2	22	196	218	6·85	72·3	0
Japan wax,	47–54	·975	2	18–28	194–198	216–222	6–7·55	69–71	0
Mineral wax,	60–80	·918–·952	0	0	0	0	0–0·6	0	100
Paraffin,	38–74	·913–·914	0	0	0	0	17–31	0	100
Resin,	53·5	1·104–1·108	0	168	10	178	135·6	35	0
Spermaceti,	40–50	·945–·96	0	0–2	136–142	136–144	—	—	—
Stearic acid,	53·5–69·2	·901–1·00	0	204	5	209	2–4	0	0
Suint wax,	62–66	—	0	95–115	4–7	102–119	13–18·5	0	14–18
Tallow,	42–50·5	·952–·96	0	2·75–5	193–208	196–213	27–40	52–60	0
Vegetable wax,	47–55·6	·947	2	17–19	200–210	218–220	6·6–8·2	73–74	0

GENERAL CONCLUSIONS.

Beeswax, in our markets, is adulterated to the extent of fifty per cent. while in the English markets the amount of adulteration rises to sixty-six and two-thirds per cent.

The melting point of beeswax varies from 62° to 64° C. It is raised by adding carnaüba wax, stearic acid, certain mineral waxes and paraffins. China wax, Japan wax, cacao butter, resin, tallow, spermaceti, vegetable wax, certain stearic acids and paraffins, lower it, while it is apparently unaltered when adulterated with suint wax, certain mineral waxes, paraffins and stearic acid.

Beeswax varies in specific gravity from ·960 to ·973 and appears to be greatly influenced only by resin, carnaüba wax and certain mineral waxes, which increase it, and by paraffin, which lowers it.

The "acid number" ranges from nineteen to twenty-one milligrams of potash per gram of beeswax. Stearic acid, resin and suint wax increase, while carnaüba wax, mineral wax, cacao butter, paraffin and spermaceti decrease the acid number. China wax, Japan wax and vegetable wax do not vitiate the number seriously.

The "ether numbers" varying from seventy-three to

seventy-six milligrams of potash per gram of beeswax, are unaffected by adding carnaüba wax; but China wax, Japan wax, cacao butter, tallow, vegetable wax increase it. Mineral wax, paraffin, resin, stearic acid and suint wax decrease it. It must be noted that wax bleached by certain chemical agents may have an ether number as high as eighty-four and yet be pure.

The percentage of iodine varies from eight to eleven, yet wax bleached by certain agents, as chlorine, may vary far from these percentages. Paraffin, mineral waxes and stearic acid lower the percentage, but cacao butter, resin, suint wax and tallow increase it. China wax, carnaüba wax, Japan wax and vegetable wax pass the prescribed limits but very little.

The volume (53· to 57·5 cubic centimetres) of hydrogen evolved from one gram of beeswax and the percentage (12·5 to 14·5) of hydrocarbons evidently are the most reliable data securable; the former being vitiated by all adulterants except tallow, and the latter by all except suint wax.

LABORATORY, SMITH, KLINE & FRENCH COMPANY,
PHILADELPHIA, PA.

THE ELECTRICAL SECTION

OF THE

FRANKLIN INSTITUTE.

[*Proceedings of the stated meeting, held Tuesday, November 28, 1893.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 28, 1893.

ELMER G. WILLYOUNG, President, in the chair.

The stated meeting of the Section was called to order by the President.

The minutes of the preceding two meetings were read and approved.

The Treasurer reported $29.14 on hand, and presented bills for postage, printing, etc., amounting to $23.46, which were ordered paid.

The names of Prof. Jos. O. Thompson, Haverford, Pa; W. Hoopes, Cynwyd, Pa.; J. Appleton, 1007 Spruce Street, Philadelphia; John Brackin, Central Manual Training School, Philadelphia; Theodore B. Lewis, 2025 Pine Street, were proposed for membership and referred to the Committee on Admissions.

A motion was read, to be submitted at the next regular meeting, to amend section 1, article vi, of the by-laws, by striking it out and substituting the following:

Immediately following the annual election of officers, the President shall appoint two members who, with the President, shall constitute a Finance Committee.

This committee shall examine all bills, and such bills, when approved by them and signed by the President, shall be paid by the Treasurer.

In the absence of the President, the chairman of the meeting shall have power to act for him.

Thomas Spencer and P. A. Mitchell were appointed by the President to audit the accounts of the Treasurer.

The following nominations were made for officers of the Section for 1894: For President, E. G. Willyoung; Vice-Presidents, Carl Hering and Prof. E. J. Houston; Secretary and Treasurer, Robert H. Laird; Conservator, Dr. Wm. H. Wahl. Upon motion, the Secretary was authorized to issue tickets for the proposed course of lectures. A motion was also made and carried that the Section assume the expenses pertaining to the lectures.

Adjourned. R. H. LAIRD, *Secretary.*

[*Proceedings of the stated meeting, held Tuesday, December 26, 1893.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 26, 1893.

ELMER G. WILLYOUNG, President, in the chair.

The stated meeting of the Section was called to order by President Willyoung.

The minutes of the meeting of November 28th were read and approved.

A motion was also made and carried that the Secretary cast the ballot of the Section for the officers nominated at the regular meeting of November 28th. Upon motion, the further business of the evening was suspended. The President then introduced Prof. H. S. Carhart, of Ann Arbor, Mich., who read a paper on "The Theory and Design of the Closed Coil Constant Current Arc Dynamo."

Adjourned. R. H. LAIRD, *Secretary.*

SUBDIVISION OF STEAMSHIPS AND SAFETY IN CASE OF INJURY.

By Andrew Ham.

[*Read at the meeting of the Section of Engineers and Naval Architects, November 23, 1893.*]

If the skin of a ship is penetrated below water, by a collision, ramming, explosion of torpedo, etc., she may founder by:

(1) The loss of her reserve buoyancy, sending the vessel straight down to the bottom.

(2) The loss of her stability, making her capsize.

Usually, only the first cause is considered, although probably many a ship was lost by the combination of the two causes, as, for instance, the *Victoria*.

The word "reserve buoyancy" means the buoyancy which the water-tight inclosed parts above the water plane can give. It is the weight of a quantity of water, equal in volume to the difference of the total cubical contents of the ship up to the upper deck and the cubical displacement. It is obvious that a vessel must ship a weight equal to the reserve buoyancy before it sinks.

Now, in a ship which has no subdivision, the water has free access to all its parts and, consequently, will flood it till its surface is on a level with the surface of the sea. This may take place without sinking when the cargo is of such a low density that it occupies most of the room in the holds and leaves but little space for the sea to fill; in other words, the ship will float on her cargo. This is, for instance, the case with wooden vessels carrying lumber, some of which are so old and leaky as to be totally unfit for any other trade.

Steel steamships, however, are of too heavy a material to float on any kind of cargo, and to protect them from sinking, the only resource we have is to localize the effects of the injury by subdividing them by means of water-tight bulkheads. Naturally these bulkheads are placed athwart

ships, but in addition to these longitudinal bulkheads may be fitted. Later on, we will see that these may become elements of danger instead of safeguards.

Water-tight subdivision is no invention of the present time, as the Chinese junks were built with bulkheads centuries ago. H. B. M. S. *Etna* and *Terror*, wooden sailing ships, were built with bulkheads as early as 1830, and these effectively prevented the *Terror* from sinking when damaged.

When steam was introduced as motive-power, the necessity of separating the machinery from the cargo holds created two bulkheads amidships. In addition to these a collision bulkhead near the stern was fitted, so that the early steamers had at least three bulkheads, dividing them into four compartments.

The Board of Trade made the fitting of bulkheads compulsory by the provisions of the Merchant Shipping Act of 1854. Lloyds Register Committee followed in 1855 by prescribing two engine-room bulkheads, and one at each end of the vessel.

Since then, as the size of the ships increased and their construction was improved, the number of bulkheads required became larger, and more stringent rules for their construction were laid down.

At present, Lloyds requires a collision bulkhead, a corresponding one near the stern, engine-room bulkheads and one in the fore hold for vessels of over 280 feet long; one in both the fore and aft holds in vessels of over 330 feet long. The question of subdivision has been thoroughly investigated by the Bulkhead Committee appointed by the Board of Trade, which brought out its report in 1891.

It classifies ships in six grades and requires a division in compartments, such that the ship keeps afloat under certain conditions, different for each grade. The first grade comprises all passenger ships over 425 feet long, and, because of the danger in crossing the track of so many other steamers, all channel steamers, irrespective of their length. They must be able to keep afloat with any two of the compartments filled, necessitating in general eight bulkheads.

Ship-owners, especially of large liners, have often fitted more bulkheads than are required either by the Board of Trade or by Lloyds, and wisely done so, for it may be said that their regulations are not sufficient when the safety of so many lives is to be insured.

It is of the highest importance to calculate in an early stage of a ship's design the probable effect of any injury done to the ship.

In these calculations we always suppose the ship to receive the damage at one of the bulkheads, so that the two adjacent compartments are flooded, this being the worst possible case.

Further, the compartments are not supposed empty but filled with cargo. Therefore, to get the weight of water admitted, a certain percentage is deducted from the weight of water which the empty compartment would ship. Or, to put it in another way, not all the buoyancy of the compartment is lost as the cargo displaces water; consequently gives buoyancy. Coal, for instance, admits forty cubic feet of water for every 100 cubic feet of space occupied. Similar deductions are made for engine and boiler space. This deduction for cargo spaces is justified by the fact that they are only empty when the ship has no cargo at all, for no captain will load his ship with a heavy cargo in all except one or two holds, and leave those empty. And when a ship is in light condition she is in general safe enough.

A question, the solution of which may be of practical use in comparing ships or in comparing the preliminary design of a ship with ships in existence, is: How will the safety of a ship be affected when we suppose some of her dimensions altered, as, for instance, her length, or width, or depth?

Let us suppose we have a ship A, having a certain distribution of bulkheads, and let this ship, in case two compartments are flooded, acquire an increase of mean draft α and an increase in total trim β.

What will be the corresponding increments for ships—

B, which is n times the size of A, all round;

C, which is n times as broad as *A*, keeping the same length and draft;

D, which is n times as long as *A*, keeping the same breadth and draft;

E, which has n times the draft of *A*, keeping the same breadth and length?

In changing the length, or breadth, or draft, I suppose the lines to be drawn out in the proportion $1 : n$ in the longitudinal, transverse or vertical direction, respectively; in other words, the character of the lines stays the same and all coëfficients are the same. Also, in changing the length, I suppose the bulkheads to be distributed in the same manner, *i. e.*, a bulkhead (say) sixty feet aft of x in *A* will be $n \times 60$ feet aft of x in *B* and *D*. The effect will be:

B will have an increase in draft $n\alpha$, will have the same angle of trim and, consequently, an increase in total trim $n\beta$.

C will have exactly the same increase in both draft and trim α and β.

D will have, approximately, the same increase in draft and the same total trim, the error being on the safe side for the longer ship.

E will have, approximately, an increase in draft $n\alpha$ and an increase in total trim $n\beta$, with the error on the safe side for the shallower ship.

So that, generally speaking, long ships are a little safer than short ships; ships with fine water lines somewhat safer than those with full lines.

Shallow ships are decidedly safer than deep-going ships, and a ship with V-formed sections will be safer than a ship with full or U-formed sections.

It is to be observed that draft and depth in hold should not be mixed up. The greater the depth in hold with the same draft, the greater are freeboard and reserve buoyancy and the safer the ship is.

As before stated, an allowance is made in the calculations for the buoyancy which the cargo gives. But there are other considerations, other factors of safety, or rather, factors of danger, which we cannot express in figures.

The vital parts of the ship are its machinery and the steering apparatus, which latter is under these circumstances of even greater importance than the propelling machinery. This, however, is generally safe, protected as it is by the overhanging upper works at the after end.

The chief advantage of twin-screw ships is found in the possibility of navigating with one set of engine and propeller when the other one is disabled. This requires a longitudinal bulkhead which should be fitted in all twin-screw steamers, and should be extra strong.

The loss of the *Victoria*, however, has shown the danger of capsizing to which a ship may be exposed by having too much of a good thing in this regard.

In an ordinary large liner the angle of heel, caused by the filling of one engine-room will not be so very large, won't exceed 15° probably. But, to counteract this, we would have to fill the water bottom on the emerging side, which would only partly right the ship, and, on the other hand, sink her deeper. Coal might be shifted, but that is neither easily nor quickly done. So that, for the time being, the ship is in a pretty awkward condition. The water pounds against the bulkhead with every roll the ship takes and may wreck it. It is true that statically it acts as a ballast, but dynamically it behaves like a mad bull; possibly throwing its momentum on the ship's side just when she takes a deep lurch, overcoming the margin of stability which is left.

If the water be confined to the engine-room the danger is not so imminent, but if the boiler-room should be flooded, too; and have a longitudinal bulkhead, it may be a serious case. Fitting longitudinal bulkheads in both engine and boiler-rooms, therefore, is inadvisable.

And even where large side bunkers are situated alongside the boiler compartments, it may be well to connect them by a trimming pipe, which may be below the fire-room floor. so that the bunkers on both sides shall become flooded.

The Bulkhead Committee considers a ship unsafe when the deck at the lower side is about three-hundredths of the depth of the ship above the water surface.

Flooding of boiler-rooms means loss of motive-power

entirely, and for that reason in large liners two boiler-rooms are necessary, and it is desirable that the arrangement should be such that (say) a couple of single-ended boilers should be put in a third compartment, which may be smaller.

The main steam pipes, running from the forward boilers to the engine, receiving on their way the steam from the after boilers, deserve a little attention, too. They should be inclosed in a separate trunk, running from the forward boiler compartment through the after one. Valves in the branch pipes to the separate boilers should be situated in or near this trunk and should be made so that they may be manipulated from the upper or main deck. The advantage of this arrangement is obvious. For suppose one compartment flooded and the steam pipes immersed, I think they would form an undesirable condensing apparatus, as ordinary coating is inadequate against the great cooling effect of water.

And, if we could not readily at all times shut off an immersed boiler from the main pipe, this boiler would act as a powerful condenser, too.

Next, we have to consider the donkey boiler, on which the dynamos, the pumps and the other auxiliary machinery depends when the main boilers are powerless. Instead of placing it low down in the ship, it should be put on the main deck and inclosed; or, if placed below, it should be given a separate room, accessible from above by a water-tight trunk. On this poor donkey boiler, which is always in the road when a design is made and is generally being kicked about till it gets in some corner, depends more than is usually supposed.

Finally, no doors should be cut in bulkheads unless absolutely necessary. In the *Columbia*, of the Hamburg-American line, no doors below the water-line are cut in any bulkhead; in the *Lucania* only a very few which were considered absolutely necessary.

Although this gives a lot of trouble to the engineers, it is necessary for safety. For water-tight doors, in perfect working condition when new, after a while get rusty, dusty

or jammed up, and in fact I am afraid that on many a ship they cannot be worked at all. Also, should they work all right in ordinary condition, they might refuse to do so when a strong water-pressure is on one side.

The transverse stability of a ship is considerably changed by the flooding of compartments. As an investigation in this direction offers some interesting points, and, I think, is new to most of us, I will briefly treat this point.

Let us first suppose that the ship is kept in the upright position by a couple of forces, this couple being equal but opposite in sense to the moment of the water in the flooded

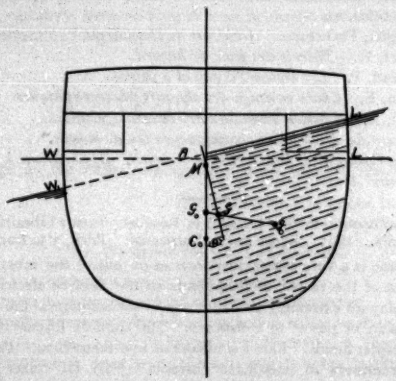


FIG. 1.

engine-room taken about a point on the centre line of the ship.

Then we may find, by known methods, a new water-line *W L*, at which the ship will be in equilibrium after having acquired a certain increase in draft and trim. For we have to treat the case simply as if the compartment were in the centre of the vessel.

It is clear that, as soon as the steadying couple ceases to act, the ship will heel over till a position of equilibrium is found, $W_1 L_1$ being the new water-line. This will be the final position which we must determine.

[*To be continued.*]

BOOK NOTICES.

Encyclopèdie scientifique des Aide-Mémoire. Paris: Librarie Gauthier-Villars et fils. Quai des Grand-Augustins. 55.

The publishers of this excellent series of technical hand-books are rapidly completing them. They will form, when completed, an extremely useful library of reference upon a wide range of subjects relating to the applications of science. Each volume is complete in itself, a feature which will be appreciated by those who are interested only in a limited number of the subjects treated of in the series; and the price, 2·50 francs, unbound, and 3 francs bound, of the separate brochures places them easily within the reach of all.

The recent additions to the series, which have lately appeared embrace the following titles, viz:

Sinigaglia, Francesco. *Accidents de chaudières.*
Laurent, H. *Théorie des jeux de hasard.*
Vermand, P. *Les Moteurs à gaz et à pétrole.*
Wallon, E. *Choix et usage des objectifs photographiques.*
Hébert, A. *Examen sommaire des boissons falsifiées.*
Guenez. *La Décoration céramique au feu de moufle.*
Naudin (Laurent). *Fabrication des vernis. Applications à l'Industrie et aux Arts.*

Les Courants Polyphasès. Par J. Rodet et Bosquet. Paris: Librairie Gauthier-Villars et fils. 1893. Large 8vo. Illustrated. Price, 3·50 francs.

This volume is a very satisfactory treatise on one of the most interesting and important of the recent developments in the field of electricity, which promises to play an extremely valuable role in the solution of the problem of the transmission of power to a distance. The authors discuss the subject under five chapter heads. Part I is historical and theoretical. Part II treats of diverse generators of polyphase currents. Part III treats of motors, synchronous and asynchronous. Part IV is devoted to transformers, and Part V to the circuits and the general subject of installation. The work is appropriately concluded by a description of the installations for long-distance transmission at Frankfort-on-the-Main, at Heilbron on the Neckar, and at Buda-Pesth. The work should be specially useful to electrical engineers.

W.

Premiers Principes d'Électricité Industrielle. Par Paul Janet, Professeur de Physique, chargé du cours d'électricité industrielle à la faculté des sciences des Grenoble. 8vo, 270 pp., 173 figures. Price, 6 francs. Paris: Libraire Gauthier-Villars et Fils. 1893.

Just why this work should have received the title it bears above is a mystery, since *principles* seem to have been but little thought of by the author in its writing. A more fitting title would have been *Une Encyclopèdie abregé.*

We are indebted to the French for much of the best scientific and engineering work that has been done; especially are we under obligations to them for many of our most authoritative published guides. It is, nevertheless, true that there is a considerable school of French scientific writers who believe that pages and pictures make up a scientific work. The publication above is of this character. Devoid of mathematical, even arithmetical treatment, some 165 pages are devoted to dynamo machines, motors and transformers; the sizes of the machines, the direction of the current in the field, etc., are given with brevity and in a juvenile vein. Voltaic cells and accumulators are described and classified in detail; the chemical reactions and considerations of power involved are, however, completely neglected. That the paper and print are excellent goes without saying, and in this respect the work can be heartily commended. Beyond this the writer can only say "every man to his taste;" if the French admire this style of literature, well and good; Americans, certainly, have no time to read it, except possibly as an exercise in reading scientific French. E. G. W.

Franklin Institute.

[*Proceedings of the stated meeting, held Wednesday, December 20, 1893.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 20, 1893.

Mr. WASHINGTON JONES in the chair.

Present, sixty-two members and twelve visitors.

Additions to membership since last report, twenty-seven.

The Secretary reported the following action taken by the Committee on Science and the Arts, at its stated meeting of December 6, 1893, viz:

The Committee on Science and the Arts reports to the Institute the following resolution and recommends its adoption:

Resolved, That the President and Secretary of the Institute be authorized to affix their signatures and the Secretary to affix the seal of the Institute to all reports of the Committee on Science and the Arts, when finally adopted by it, setting forth that such reports are the action of the Franklin Institute, by its Committee on Science and the Arts.

The resolution was thereupon presented to the meeting, and on being put to a vote was adopted without dissent.

The following nominations were made:

For *President*	(to serve one year), . . .	JOSEPH M. WILSON.
" *Vice-President*	(" three years), . . .	W. P. TATHAM.
" *Secretary*	(" one year), . . .	WM. H. WAHL.
" *Treasurer*	(" " "), . . .	SAMUEL SARTAIN.
" *Auditor*	(" three years), . . .	W. O. GRIGGS.

For the *Board of Managers* (to serve three years).

ARTHUR BEARDSLEY,	*HENRY BOWER,	CHAS. A. BRINLEY,
WM. BURNHAM,	CHAS. G. DARRACH,	*HENRY R. HEYL,
*H. W. JAYNE,	M. R. MUCKLE, JR.,	*HENRY PEMBERTON, JR.,
HORACE PETIT,	*WM. SELLERS.	

For the *Committee on Science and the Arts* (to serve three years).

H. BRINTON,	SPENCER FULLERTON,	S. P. SADTLER,
JOHN E. CODMAN,	W. C. HEAD,	CLARENCE B. SCHULTZ,
H. F. COLVIN,	HENRY R. HEYL,	THOS. SHAW,
THOS. P. CONARD,	FRED. E. IVES,	E. G. WILLYOUNG,
CHAS. B. DUDLEY,	C. L. PRINCE,	PAUL A. WINAND.

Mr. Pedro G. Salom presented a communication on the results recently obtained in Germany and elsewhere abroad by the use of the storage battery in central station work, which exhibited decided advantages in respect of economy and general efficiency over the usual system of transmission by generators. (Referred for publication.)

Prof. Lewis M. Haupt, by request, presented a paper, entitled "The Manchester Ship Canal and its Moral." In this paper the author stated the reasons which appeared sufficient to justify the city of Manchester to assume the responsibility of expending the enormous sum of $75,000,000 for the construction of a ship canal (thirty-five and one-half miles long) and auxiliary works. He gave a brief outline of the engineering features of the work referred to, the great difficulties encountered in its construction, the large interests enlisted in opposing its progress, and the economies to be secured by its completion, in avoiding the payment of the terminal charges of Liverpool and of the railroads. The speaker made use of the example of the Manchester Canal to show by comparison how much more important would be the beneficial results flowing from a ship canal connecting Long Island Sound with the Chesapeake Bay. The paper was discussed by Messrs. Salom, Smith, Fullerton and Eldridge, and was referred to the Committee on Publications. A vote of thanks to the author for his interesting and suggestive paper was unanimously passed.

Mr. T. Carpenter Smith gave a description of the new Westinghouse incandescent electric lamp, with removable base, and illustrated his remarks by an interesting series of specimens. The subject was discussed by Messrs. Eldridge, Salom, the Secretary and the author.

Mr. S. Lloyd Wiegand gave a description of the type-writing machine invented by Jas. D. Dougherty. This is a machine of the type-bar class, embodying, in the speaker's estimation, a number of substantial improvements. The speaker illustrated the subject by use of lantern slides, models of details, and the exhibition of a working machine.

On motion, the invention was referred to the Committee on Science and the Arts for investigation.

The Secretary made a brief report, whereupon the meeting was adjourned.

WM. H. WAHL, *Secretary.*

* Retiring members.

PENNSYLVANIA STATE WEATHER SERVICE,

UNDER THE DIRECTION OF THE FRANKLIN INSTITUTE,

CO-OPERATING WITH THE

UNITED STATES DEPARTMENT OF AGRICULTURE, WEATHER BUREAU

T. F. TOWNSEND, WEATHER BUREAU, L. F. O. IN CHARGE.

MONTHLY WEATHER REVIEW.

FOR NOVEMBER, 1893.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 30, 1893.

GENERAL REVIEW.

November's normal temperature and rainfall is about 40°·2 and 3·33 inches. The present month has been 1°·1 colder than the average, and the rainfall nearly half of an inch less.

The warmest period was during the first half, and the coldest occurred during the latter part of the month.

General rains prevailed on the 4th, 15th, 21st, 22d and 28th, being heavy on 4th and 28th.

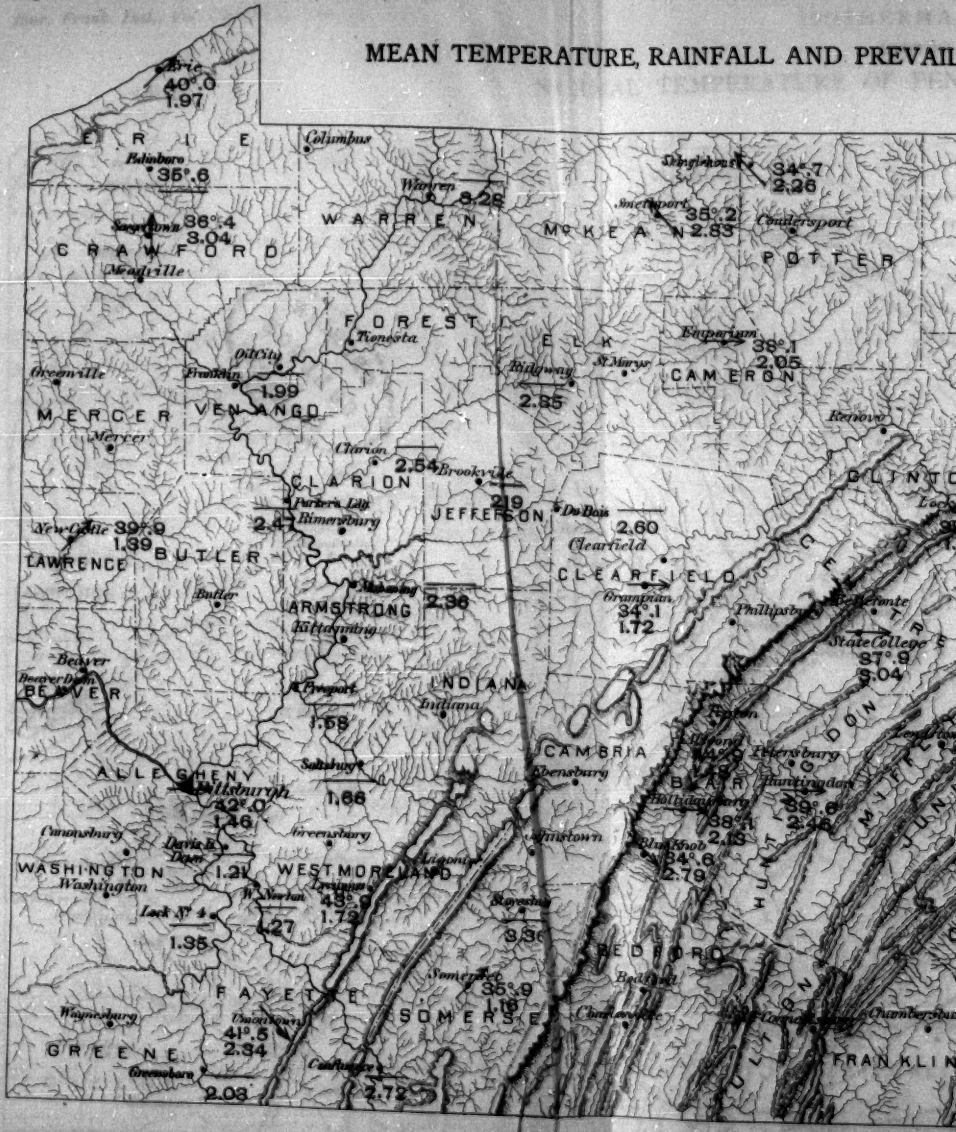
Light snows occurred on various days, but Saegertown, Carlisle and Girardville were the only stations that reported any on ground at the end of the month.

No unusual phenomena was noticed during November and the month was not exceptional.

From January 1, 1893, to November 30, 1893, the deficiency in temperature was, at Philadelphia, 324°; Pittsburgh, 486°; Erie, 401, and York, 417°.

For the same period the deficiency in precipitation was, at Philadelphia, 3·34; York, 7·35; Erie, 1·99, and excess at Pittsburgh, 0·43 inch.

MEAN TEMPERATURE, RAINFALL AND PREVAIL

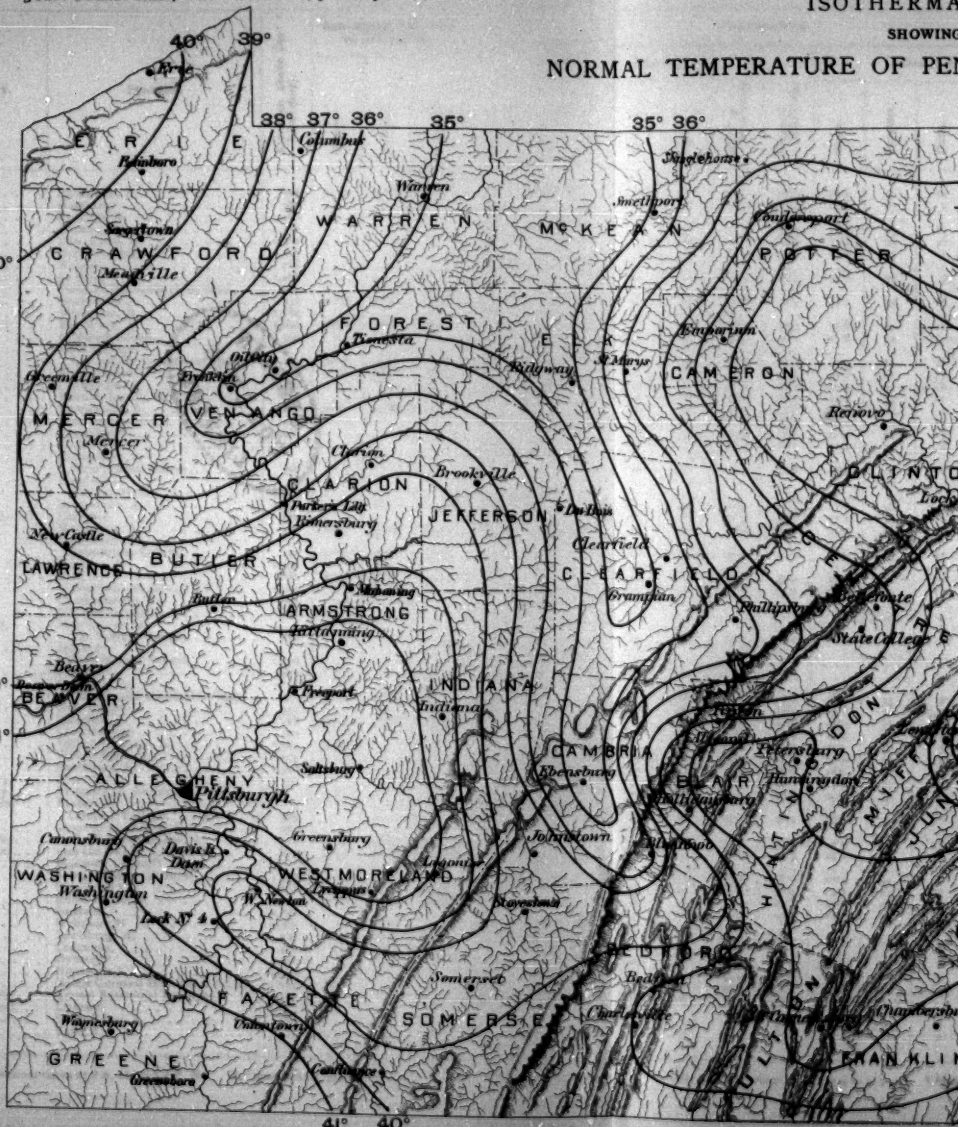


AILING WIND DIRECTION FOR NOVEMBER. 1893

ISOTHERMA

SHOWING

NORMAL TEMPERATURE OF PE



MAL LINES,
ING THE
ENNSYLVANIA FOR NOVEMBER.

Monthly Summary of Reports by Voluntary Observers of th

County.	Station.	Elevation above Sea Level (feet).	Barometer Reduced to Sea Level.			Temperature.								D
							Maximum.		Minimum.					
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.
Allegheny,	Pittsburgh, A,	820	30·12	30·68	29·60	42·0	68	2	16	26	50·2	33·0	17·2	31
Berks,	Hamburg,	380	. . .	. . .	. . .	40·5	62	2, 6, 9	19	21	48·0	33·0	15·0	29
Berks,	Reading, A,	280	. . .	. . .	. . .	39·5	. . .	. .	. .	. .	. . .	. . .	. . .	. .
Blair,	Altoona, B,	1,181	. . .	. . .	. . .	44·9	63	3	20	26	51·8	37·0	15·8	25
Blair,	Blue Knob, A,	2,500	. . .	. . .	. . .	34·6	58	2	0	26	43·0	29·2	10·8	26
Blair,	Hollidaysburg,[1]	947	. . .	. . .	. . .	38·1	65	2	5	26	49·0	25·2	23·8	43
Bradford,	Wysox[1],	718	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. . .	. . .	. . .	. .
Bradford,	Le Roy,	1,400	. . .	. . .	. . .	36·8	62	7	18	26	44·3	29·3	15·0	31
Bucks,	Forks of Neshaminy[1] (25 days),	304	. . .	. . .	. . .	41·2	. . .	. .	. .	. .	. . .	. . .	. . .	. .
Bucks,	Quakertown,[1]	536	30·16	30·76	29·72	39·3	62	2	15	27	49·8	30·7	19·1	32
Cambria,	Johnstown, A,	1,184	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. . .	. . .	. . .	. .
Cameron,	Emporium, A,	1,050	30·06	30·62	29·49	38·1	63	2	18	17	46·5	29·7	16·8	37
Carbon,	E. Mauch Chunk,	550	. . .	. . .	. . .	39·0	60	2, 9	15	27	47·9	30·1	17·8	32
Centre,	State College[1]— Agricultural Experiment Station,	1,191	30·07	30·66	29·35	37·9	59	9	13	26	46·2	26·7	19·5	27
Chester,	West Chester,[1]	455	30·11	30·62	29·65	41·3	60	2	21	26	49·0	34·2	14·8	27
Chester,	Coatesville,[1]	380	. . .	. . .	. . .	39·4	66	2	15	27	51·5	30·1	21·4	37
Chester	Kennett Square, A,	375	. . .	. . .	. . .	41·1	65	2	16	27	51·3	30·9	20·4	35
Chester,	Phœnixville, A,	190	30·15	30·68	29·74	42·1	63	18	19	27	50·5	33·7	16·8	28
Chester,	Westtown (29 days),	350	. . .	. . .	. . .	39·1	62	1	18	25	47·8	30·4	17·4	36
Clearfield,	Grampian,[*1]	1,450	. . .	. . .	. . .	34·1	56	9	8	26	40·4	28·3	12·1	28
Clinton,	Lock Haven,[1]	560	. . .	. . .	. . .	38·7	65	9	17	17	48·4	28·0	20·4	32
Columbia,	Bloomsburg, A— State Normal School,	500	. . .	. . .	. . .	40·0	65	6, 13	19	26	48·2	31·8	16·4	29
Crawford,	Meadville— Divinity Hall,[1]	1,200	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. . .	. . .	. . .	. .
Crawford,	Saegertown, A,	1,200	. . .	. . .	. . .	36·4	65	2	— 4	26	47·4	25·3	22·1	36
Cumberland,	Carlisle,[1]	480	. . .	. . .	. . .	38·0	61	6	15	26	47·3	30·1	17·2	30
Dauphin,	Harrisburg, A,	361	30·15	30·68	29·76	40·0	59	9	22	27	47·0	34·0	13·0	26
Delaware,	Swarthmore, A— Swarthmore College,	190	30·14	30·71	29·74	41·9	61	18	20	26, 27	48·8	35·0	13·8	29
Erie,	Edinboro,[*1]	1,400	. . .	. . .	. . .	35·6	56	2	13	26	. . .	. . .	. . .	. .
Erie,	Erie, A,	681	30·05	30·65	29·50	40·0	65	2	19	25	47·0	34·0	13·0	22
Fayette,	Uniontown[1] (28 days),	1,000	. . .	. . .	. . .	41·5	65	10	15	26	49·8	33·2	16·6	29
Franklin,	Chambersburg,[2]	618	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. . .	. . .	. . .	. .
Fulton,	McConnellsburg,[1]	875	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. . .	. . .	. . .	. .
Huntingdon,	Huntingdon, A— The Normal College,	650	. . .	. . .	. . .	32·6	64	2	10	26	51·1	28·2	22·9	38
Indiana,	Indiana— State Normal School,	1,350	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. . .	. . .	. . .	. .
Juniata,	Kilmer,[3*]	475	. . .	. . .	. . .	40·6	60	6	19	26	. . .	. . .	. . .	. .
Lancaster,	Lancaster, A— Franklin and Marshall College,	411	30·14	30·65	29·72	40·2	65	2	20	26	49·7	30·8	18·9	33
Lawrence,	New Castle,[1]	932	. . .	. . .	. . .	39·9	62	2, 9	9	26	47·8	27·0	20·8	36
Lebanon,	Lebanon, A,	458	30·12	30·65	29·73	40·6	63	9	18	26	49·0	31·0	18·0	30
Lehigh,	Coopersburg,[1]	580	. . .	. . .	. . .	39·8	58	2, 6, 18	19	27	49·4	31·8	16·6	27
Luzerne,	Drifton (23 days), A,	1,683	30·06	. . .	. . .	37·6	63	10	12	17	48·8	26·3	22·5	41
Luzerne,	Wilkes-Barre, A,	575	. . .	. . .	. . .	39·9	66	1	18	27	50·4	29·4	21·0	39
McKean,	Smethport, A,	1,500	. . .	. . .	. . .	35·2	64	2	10	17	44·2	26·2	18·0	42
Montgomery,	Pottstown,	150	. . .	. . .	. . .	42·4	63	18	21	27	50·2	34·5	15·7	29
Montgomery,	Skippack, A (20 days),	. . .	. . .	. . .	. . .	41·5	62	18	20	26	53·4	29·6	23·8	33
Northampton,	Easton— Lafayette College,	325	. . .	. . .	. . .	40·0	58	3, 9	18	26	47·3	30·4	16·9	32
Perry,	(Aqueduct) Logania,[*1]	367	. . .	. . .	. . .	39·4	59	9	19	26	. . .	. . .	. . .	. .
Philadelphia,	U. S. Weather Bureau, A,	117	30·14	30·66	29·73	44·0	62	2	24	26	50·2	37·7	12·5	24
Philadelphia,	1529 Centennial Avenue, A,	120	30·14	30·66	29·72	44·3	63	6	25	26	51·4	37·3	14·1	24
Pike,	Blooming Grove,[*1]	. . .	. . .	. . .	. . .	34·8	57	11	18	20, 26	. . .	. . .	. . .	. .
Potter,	Shingle House (28 days),	1,475	. . .	. . .	. . .	34·7	60	9	12	17, 21	43·4	26·0	17·4	32
Schuylkill,	Girardville,	1,000	30·08	30·61	29·67	39·0	58	9	23	26	47·2	32·9	14·3	24
Snyder,	Selins Grove, A,	455	30·16	30·65	29·89	39·1	60	2	18	26	46·4	29·8	16·6	28
Somerset,	Somerset,[1]	2,250	. . .	. . .	. . .	35·9	63	2	6	26	46·3	27·6	18·7	33
Tioga,	Wellsboro,[*1]	1,387	. . .	. . .	. . .	33·5	60	6	18	21, 26	. . .	. . .	. . .	. .
Union,	Lewisburg, A,	450	30·13	30·58	29·75	38·3	61	6	16	27	48·1	28·5	19·6	34
Warren,	Columbus,	1,410	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. . .	. . .	. . .	. .
Wayne,	Dyberry,[1]	1,100	. . .	. . .	. . .	35·0	65	2, 11	10	27	45·3	26·9	18·4	39
Wayne,	Honesdale,[1]	1,000	. . .	. . .	. . .	36·8	58	2	12	27	45·7	27·9	17·8	32
Wayne,	(Salem Corners) Hamlinton[1] (23 d.),	1,600	. . .	. . .	. . .	34·0	56	9	18	26	40·9	28·2	12·7	21
Westmoreland,	(Immel Reservoir) Lycippus,[*1]	1,400	. . .	. . .	. . .	43·9	62	2, 6	24	26	. . .	. . .	. . .	. .
Westmoreland,	Ligonier,	1,750	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. . .	. . .	. . .	. .
Wyoming,	South Eaton, A,	660	. . .	. . .	. . .	38·8	62	2	20	26, 27	47·4	30·1	17·3	30
York,	York, A,	385	30·10	30·56	29·73	40·5	63	29	17	26	50·1	31·0	19·1	34

A, Observations taken at 8 A. M. and 8 P. M. B, Observations taken at 12 Noon. * Extremes from dry thermometers. [1] Mean temperatures, 7 + 2 + 9 + 9 + 4.

Daily Range.				Relative Humidity.	Dew Point.	Precipitation.			Number of Days.				Wind.			Observers.
Greatest.	Date.	Least.	Date.			Total Inches.	Total Snowfall During Month.	Depth of Snow on Ground at End of Month.	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	Prevailing Direction. 7 A. M.	2 P. M.	9 P. M.	
31	12	6	4	74·0	33·0	1·46	. . .	. . .	8	12	10	8	W	. . .	W	O. D. Stewart, Weather Bureau
29	1	0	4	. . .	. . .	3·54	. . .	. . .	4	2	22	6	NW	. . .	. . .	William Shipe.
. .	. .	. .	. .	. . .	. . .	4·39	. . .	. . .	12	. .	. .	. .	. .	. .	. .	Franklin Yager.
35	17	6	5	. . .	. . .	1·48	. . .	. . .	6	. .	. .	. .	. .	. .	. .	Dr. C. B. Dudley.
26	26	2	24	. . .	. . .	2·79	11·5	. . .	11	5	12	13	NW	. . .	NW	A. H. Boyle.
43	2	7	4	. . .	. . .	2·13	1·5	. . .	5	10	12	8	W	W	W	Prof. J. A. Stewart.
. .	. .	. .	. .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	Charles Beecher.
31	7	1	4	. . .	. . .	2·07	3·0	. . .	13	3	13	14	SW	SW	SW	G. W. T. Warburton.
. .	. .	. .	. .	. . .	. .	4·06	. .	. .	10	8	13	4	W	W	W	J. C. Hilsman.
32	27	7	24	. . .	. . .	1·44	1·0	. . .	9	7	13	10	NE	NW	SW	J. L. Heacock.
. .	. .	. .	. .	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .	. .	. .	E. C. Lorentz.
37	17	3	4	90·1	32·0	2·05	1·5	. . .	11	3	12	15	W	. . .	W	T. B. Lloyd.
32	1, 2	3	4	. . .	. . .	3·26	. . .	. . .	9	8	8	14	N	. . .	. . .	F. C. Wintermute.
27	22	6	17, 25	80·2	31·9	3·04	4·0	. . .	8	3	15	12	W	W	W	Prof. Wm. Frear.
27	27	5	8	72·0	32·3	4·76	0·5	. . .	10	13	4	13	S	NW	N	J. C. Green, D.D.S.
37	2	7	28	. . .	. . .	3·69	1·2	. . .	10	13	9	8	W	W	W	W. T. Gordon.
35	11	4	8	. . .	. . .	4·34	0·5	. . .	10	7	10	13	SW	. . .	SW	B. P. Kirk.
28	1	7	24	79·0	32·7	4·74	. . .	. . .	10	9	5	16	NW	. . .	NW	Knowles Croskey.
36	11	5	5	. . .	. . .	. . .	. . .	. . .	. .	9	9	11	W	W	W	Harry Alger.
28	17	3	4, 28	. . .	. . .	1·72	2·0	. . .	7	7	11	12	W	W	W	Nathan Moore.
28	2	5	24	. . .	. . .	1·53	1·0	. . .	8	7	10	13	W	W	W	Prof. J. A. Robb.
29	28	6	24, 25	79·3	32·8	1·44	0·1	. . .	6	6	12	12	NW	. . .	NW	Prof. J. G. Cope.
. .	. .	. .	. .	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .	Chas. Graves.
36	7, 25	7	25	. . .	. . .	3·04	8·0	4·0	12	5	6	19	S	. . .	SW	J. G. Apple.
30	1	6	4	. . .	. . .	3·09	3·5	1·0	7	10	12	8	W	W	W	J. E. Pague.
26	2	3	4	79·0	33·0	2·54	0·8	. . .	10	10	9	11	W	. . .	W	F. Ridgway, Weather Bureau.
29	27	4	24	86·0	35·6	4·04	. . .	. . .	4	7	17	6	NW	. . .	NW	Prof. Susan J. Cunningham.
. .	. .	. .	. .	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .	C. F. Sweet.
22	9	5	25	70·0	30·0	1·97	. . .	. . .	15	6	13	11	SW	. . .	SW	P. Wood, Weather Bureau,
29	12	5	4, 18	. . .	. . .	2·34	0·5	. . .	8	13	8	7	SW	NW	NW	Wm. Hunt.
. .	. .	. .	. .	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .	G. W. Ludwig.
. .	. .	. .	. .	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .	T. F. Sloan.
38	2, 17	7	24	. . .	. . .	2·46	1·5	. . .	7	16	4	10	W		W	Prof. W. J. Swigart.
. .	. .	. .	. .	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .	Prof. S C. Schmucker.
. .	. .	. .	. .	. . .	. . .	3·42	1·0	. . .	9	7	10	13	W	. . .	. .	R. J. Mickey.
33	2	7	4	81·2	34·8	3·76	1·0	. . .	10	13	8	9	W	. . .	E	W. E. Bushong.
36	9, 12	8	28	. . .	. . .	1·39	4·0	. . .	6	9	8	13	NW	SW	W	Wm. T. Butz.
30	1	8	24	89·7	34·1	3·42	2·2	. . .	10	12	12	6	SW	. . .	SW	G. W. Hayes, C.E.
27	27	9	4, 5, 28	. . .	. . .	3·89	1·0	. . .	9	10	9	11	SE	SE	SE	Dr. M. H. Boye.
41	3	4	15	85·0	35·0	2·58	8·2	. . .	10	6	11	6	. .	. .	. .	J. R. Wagner.
39	1	8	24	. . .	. . .	2·97	3·0	. . .	6	14	3	13	W	. . .	W	A. W. Betterly.
42	17	4	23	. . .	. . .	2·83	13·0	. . .	9	4	13	13	SW	. . .	SE	Armstrong & Brownell.
29	1	2	31	73·0	33·4	4·78	. . .	. . .	6	13	10	7	W	W	W	Charles Moore, D.D.S
33	12	6	4	. . .	. . .	4·21	. . .	. . .	6	10	5	5	W	. . .	W	B. W. Dambly.
. .	. .	. .	. .	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .	J. W. Moore.
32	27	4	4	. . .	. . .	3·21	0·2	. . .	8	. .	. .	. .	. .	. .	. .	Richard Callin.
. .	. .	. .	. .	. . .	. . .	3·14	1·2	. . .	7	10	8	12	NW	. . .	. .	L. M. Dey, Weather Bureau.
24	27	4	4	71·0	34·0	2·51	. . .	. . .	8	8	14	8	NW	. . .	NW	John Comly.
24	27	5	8, 13	74·2	33·7	3·81	. . .	. . .	9	10	10	10	NW	. . .	NW	John Grathwohl.
. .	. .	. .	. .	. . .	. . .	3·95	. . .	. . .	6	. .	. .	. .	. .	. .	. .	C. D. Voorhees, M.D.
32	6	4	25	. . .	. . .	2·26	6·6	. . .	12	6	6	16	SE	. . .	. .	E. C. Wagner.
24	11	4	4	. . .	. . .	3·57	6·8	2·0	9	6	18	6	W	W	W	J. M. Boyer,
28	2	9	3	89·6	33·6	2·45	1·5	. . .	6	0	20	10	NW	. . .	NW	W. M. Schrock.
33	2	8	25	90·4	35·0	1·16	2·2	. . .	7	4	6	20	SW	SW	SW	H. D. Deming
. .	. .	. .	. .	. . .	. . .	3·00	3·5	. . .	5	3	9	16	N	S	S	Prof. W. G. Owens.
34	2	6	24	89·3	31·8	1·71	0·5	. . .	4	5	16	9	S	. . .	S	Wm. Loveland.
. .	. .	. .	. .	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .	Theodore Day.
30	2	4	25	. . .	. . .	2·17	7·5	. . .	6	4	15	11	W	W	W	John Torrey.
32	1	7	4, 25	. . .	. . .	2·49	2·0	. . .	7	. .	. .	. .	. .	. .	. .	T.B. Orchard, M.D.
21	11	3	28	. . .	. . .	2·74	6·0	. . .	5	1	12	10	W	W	W	Murray Forbes.
. .	. .	. .	. .	. . .	. . .	1·72	. . .	. . .	6	. .	. .	. .	. .	. .	. .	J. T. Ambrose.
. .	. .	. .	. .	. . .	. . .	. . .	. . .	. . .	. .	. .	. .	. .	. .	. .	. .	B. M. Hall.
30	7	6	4, 25	. . .	. . .	1·94	. . .	. . .	7	9	13	8	NW	. . .	NW	Mrs. L. H. Grenewald
34	2	7	5	88·7	35·1	3·55	2·0	. . .	8	12	8	10	NW	. . .	NW	

+ 4. [2] Mean of 8 + 8 + 2. [3] Mean of 7 + 7 + 2. Absence of numerals indicates that mean of temperature is from maximum and minimum readings.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total.
Delaware Basin.																																
Blooming Grove,			.14	.60					.56				.04		.38			.60			.47							1.76				3.95
Browers Lock,				1.73	.38								.04		.47							.56						1.07				4.81
Coatesville,				1.60	.30			.88	.47				.05		.60			.02			.43	.25						1.02				5.69
Coopersburg,				1.61	.11			.01					.03		.39			.01			.38	.29						1.06				3.89
Doylestown,				2.00	.19			.11	.13				.05		.41						.06	.46						1.09				4.50
Dyberry,			.15	.30											.30						.25	.10						1.07				2.17
Easton,			.01		1.15								.02	.02	.43			.01				.62						.95				3.21
Forks of Neshaminy,			.03		1.75			.27	.27				.03	.01	.43						.13	.39						.95				4.06
Frederick,				1.97	.28			.13	.19				.04		.50						.21	.33						.90				4.48
Hamburg,				1.60																	.81							.72				3.54
Honesdale,			.13	.55										.41							.40							1.04				2.49
Kennett Square,				.79	.41			.13	.63				.09	.01	.60						.40	.37						.91				4.34
Lansdale,				2.00	.25			.41	.25				.03		.40						.25	.17					.91					4.67
Mauch Chunk,			.03	.93	.13										.24			.02	.02		.03	.67						1.19				3.96
Ottsville,				1.70	.45								.04								.02	1.00						.93				4.19
Philadelphia, a†				.40	.26				.42				.05		.43						.18	.38						.39				2.51
Philadelphia, b,				.75	.38			.02	.61				.06		.49						.23	.53						.74				3.81
Phœnixville,				2.03	.11			.32	.28				.05		.52			.01			.21	.31						.90				4.74
Point Pleasant,				1.96	.27		.05	.04							.42						.25	.42						.99				4.40
Pottstown,				2.25				.38					.05		.40							.60						1.10				4.78
Quakertown,				1.97	.19			.05	.03				.05		.30						.58	.50						.97				4.44
Reading,				1.35	.20			.01	.10				.01		.43			.01			.25	.27					.01	.75				3.39
Salem Corners,	*	*	*	*	*	*	*							.04				.25	.05			.36						1.44				2.14
Seisholtzville,				1.69	.12										.38																	
Skippack,				2.25			*	.38					.47	*	.50				*		.24	.37	*	*			1.05		*	*		3.95
Smith's Corner,				1.95	.30								.05		.43						.50	*						.53				4.21
Swarthmore,				1.50									.09		.43						.20	.45						1.05				3.47
West Chester,				1.41	.30			.34	.44				.06	.04	1.17							.80						.57				4.01
Westtown,															.43						.60	.07						1.07				4.76
Susquehanna Basin.																																
Altoona,			.02	.45	.18																	.09						.68		.06		1.48
Aqueduct,			.01	1.59									.08	.16							.23	.10					1.00	.10				3.14
Bloomsburg,			.09	.96											.01						.22							.66				1.44
Blue Knob,			.50	.88									.01		.40			.02			.22		.25	.05	.05			.26		.15		2.79
Carlisle,				1.45	.54				.04						.22			.02				.62						1.06				2.92
Drifton,			.04	.42	*	.75						*		.04	.40			.50	.08		.10	.20			.05	*	*	*		*		2.58
Emporium,			.17	.42									.03				.02	.06			.16	.25					.07	.83	.03	.01		2.05
Gettysburg,				.66					.25						.17							.31						.88				2.97
Girardville,			.04	1.13							.02				.36			.16	.03		.40						.50	.64				3.57
Grampian,				.50														.18		.02	.15	.22					.28	.37				1.72
Harrisburg,†				1.20	.12			.04	.02						.12			.13			.30	.14						.46		.01		2.54
Hollidaysburg,				.83																	.30						.32	.62		.06		2.13
Huntingdon,				.90	.08																.23	.15					.05	1.00		.05		2.46
Kilmer,			.06	1.22									.02		.07			.02			.69						.80	.48	.06			3.42
Lancaster,				1.61	.26			.13	.30				.03		.30			.04			.16	.19						.66				3.76
Lebanon,			.02	1.38	.12			.02	.09						.31			.02			.39	.24						.98				3.42
Le Roy,			.08	.26	.01								.02					.04	.02	.03	.20	.20			.05		.10	1.01	.05			2.07
Lewisburg,				.77											.16						.05							.73				1.71
Lock Haven,			.13	.47									.01		.05						.05	.17					.25	.40				1.53
Selins Grove,			.54	1.11	.09																.05	.11						.55				2.45
South Eaton,			.08	.57											.19			.11			.20	.28						.31				1.94
State College,			.04	.92	.09								.03		.70						.42						.21	.70				3.04
Wellsboro,			.05	.25																	.33						.10	2.25				3.00
Wilkes-Barre,			.20	.75											.27			.12			.14							1.39				2.97
Wysox,																																
York,				1.11	.41			.48	.18						.33						.26	.15						.63				3.55

†U. S. Weather Bureau Stations. *Missing.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total.
Ohio Basin.																																
Beaver Dam,				.31	.47													.08				.47						.68	.07	.11		2.19
Clarion,			.01	.20	.13												.02	.19	.05	.05		.66		.02	.05			1.01	.06	.03		2.54
Columbus,																																
Confluence,			.02	1.05	.60										.05	.01	.01		.04		.25						.32		.37		2.72
Davis Island Dam,				.22	.10											.01			.05	.08	.32						.35	.02	.06		1.21
DuBois,			.11	.14														.15	.04	.46	.09						1.13	.04	.44		2.60
Freeport,			.03	.19	.20																	.52					.55		.09		1.58
Greensboro,				.62	.33										.07				.16			.25					.33	.02	.25		2.03
Immel Reservoir,			.06	.88														.20			.16	.17					.25				1.72
Indiana,																																
Johnstown,																																
Ligonier,																																
Lock No. 4,			.05	.08	.28											.06		.03	.06			.36			.01			.30	.01	.11		1.35
Mahoning,			.03	.23	.16									.04				.12	.05			.38				.01		1.04	.02	.08		2.36
Meadville,																																
New Castle,																		.20	.05		.37					.09		.70	.05			1.39
Oil City,			.02													.03		.12	.01	.02		.62			.08			.92	.03	.14		1.99
Parker's Landing,			.03	.10	.13									.08		.01		.12	.09			.62		.01	.01			1.19	.02	.06		2.47
Pittsburg,†				.28														.09			.22	.10		.03			.55	.09		.10		1.46
Ridgway,		.10	.21	.21												.01					.61						.99	.03	.05	.14		2.35
Saegertown,			.35										.05		.20	.25		.22	.05		.17	.15	.03				.99	.22	.36			3.04
Saltsburg,			.02	.25	.36										.02	.01		.02	.10			.18						.58		.12		1.66
Shingle House,		*	*		.14								.05			.20		.11	.04	.18	.20	.10		.05				1.10	.02	.07		2.26
Smethport,				.33	.20											.20		.25		.30	.20	.55		.20	.60							2.83
Somerset,				.10	.45										.17									.06			.20	.03	.15			1.16
Stoyestown,				.21	.84										.21	.10			.10		.20	.08		.17			.47	.68	.22	.08		3.36
Uniontown,		*	*		1.15								.02		.06			.14			.18						.57	.05		.17		2.34
Warren,				.40										.01		.19	.01	.40	.02	.10		.52	.03	.10	.20	.02		.93	.05	.30		3.28
West Newton,			.07	.10	.25														.11			.30						.30		.14		1.97
Potomac Basin.																																
Chambersburg,																																
McConnellsburg,																																
Lake Basin.																																
Erie,†				.17									.12		.18	.06		.10	.02		.20	.08	.05	.16	.08		.46	.05	.20	.04		1.97

	Mean Temperature.	*Mean Precipitation. Inches.*
November, 1887,	39°·2	1·80
1888,	42°·0	3·37
1889,	41°·0	6·72
1890,	41°·5	1·49
1891,	39°·6	2·65
1892,	39°·1	4·34
1893,	39°·1	2·93

TEMPERATURE.

The mean temperature for November, 1893, was 39°·1, which is 1°·1 below the normal, and the same as the corresponding month of 1892.

The mean of the daily maximum and minimum temperatures, 48°·0 and 30°·5, gives a monthly mean of 39°·2, with an average daily range of 17°·5.

Highest monthly mean, 44°·9 at Altoona.

Lowest monthly mean, 33°·5 at Wellsboro.

Highest temperature recorded during the month, 68° on the 2d at Pittsburgh.

Lowest temperature, minus 4° on the 26th at Saegertown.

Greatest local monthly range, 69° at Saegertown.

Least local monthly range, 35° at Girardville.

Greatest daily range, 43° at Hollidaysburg on the 2d.

Least daily range, 0° at Hamburg on the 4th.

BAROMETER.

The mean pressure for the month, 30·12, is about ·07 above the normal. At the United States Weather Bureau Stations, the highest observed was 30·68 at Pittsburgh and Harrisburg on the 26th, and the lowest 29·50 at Erie on the 21st.

PRECIPITATION.

The average rainfall, 2·93 inches for the month, is a deficiency of 0·40.

The largest monthly totals in inches were Coatesville, 5·69; Browers Lock, 4·81; Pottstown, 4·78; West Chester, 4·76; Phœnixville, 4·74, and Lansdale, 4·67.

The least were Somerset, 1·16; Davis Island Dam, 1·21; West Newton, 1·27; Lock No. 4, 1·35, and New Castle, 1·39.

WIND AND WEATHER.

The prevailing wind was from the West.

Average number: rainy days, 8; clear days, 8; fair days, 11; cloudy days, 11.

MISCELLANEOUS PHENOMENA.

Thunder.—Saegertown, 2d.

Hail.—Emporium, 22d.

Sleet.—Blue Knob, 21st, 23d, 27th, 28th; Huntingdon, 21st.

Snow.—Altoona, 15th, 22d; Blue Knob, 4th, 14th, 15th, 18th, 21st, 23d, 24th, 25th, 29th, 28th; Hollidaysburg, 15th, 21st; Le Roy, 4th, 19th, 20th, 21st, 24th, 25th, 26th; Quakertown, 15th, 21st, 25th; Emporium, 4th, 15th, 16th, 19th, 20th, 21st, 23d, 24th, 25th, 28th; Mauch Chunk, 15th; State College, 15th, 21st; West Chester, 15th; Coatesville, 15th, 21st; Kennett Square, 15th; Grampian, 20th, 21st; Lock Haven, 19th, 21st; Bloomsburg, 15th, 19th, 20th, 22d, 25th; Saegertown, 15th, 16th, 19th, 23d, 24th; Carlisle, 15th, 22d; Huntingdon, 21st; Kilmer, 15th, 21st; Lancaster, 15th; New Castle, 15th, 26th; Lebanon, 15th, 21st; Coopersburg, 15th, 21st; Drifton, 15th, 19th, 20th, 21st, 22d, 25th; Wilkes-Barre, 15th, 20th, 21st, 25th; Skippack, 15th; Logania, 21st; *Philadelphia* [Centennial Avenue], 15th 20th, 24th, 25th, 27th; Shingle House, 15th, 16th, 19th, 20th, 21st, 24th; Girardville, 15th, 19th, 21st; Selins Grove, 21st; Somerset, 15th, 24th, 28th; Dyberry, 4th, 15th, 21st, 22d; Honesdale, 15th, 21st; South Eaton, 22d; York, 15th, 21st.

Aurora.—Le Roy, 1st; Lebanon, 1st; Selins Grove, 1st; Dyberry, 1st.

Coronæ.—Blue Knob, 26th; Emporium, 18th, 19th, 20th, 22d; Saegertown, 14th; Lebanon, 6th, 19th, 20th, 22d, 23d, 24th; Dyberry, 26th.

Solar Halo.—Le Roy, 1st; Westtown, 1st, 7th; *Philadelphia* [Weather Bureau], 1st, 7th, 29th; [Centennial Avenue], 1st, 7th; Wellsboro, 14th; Dyberry, 7th, 14th.

Lunar Halo.—Hollidaysburg, 18th, 26th; Lancaster, 26th; *Philadelphia*, [Centennial Avenue], 18th, 19th.

Meteors.—Blue Knob, 25th; *Philadelphia* [Centennial Avenue], 10th, 18th, 19th; Dyberry, 30th; State College, 1st, 10th, 16th.

JANUARY WEATHER.

From United States Weather Bureau Records.

The following data, compiled from the records of observations taken during the length of time given at each station, show the average and extreme conditions during that time, and also the range within which weather variations may be expected to keep in any future January.

	Philadelphia. (23 years.)	Pittsburgh. (22 years.)	Erie. (19 years.)
Mean or normal,	32°	31°	28°
Warmest January,	1890	1880	1880
Average,	42°	44°	40°
Coldest January,	1893	1875	1875
Average,	24°	23°	19°
Highest temperature recorded,	72°	71°	73°
Date,	12th, 1890	13th, 1890	1st, 1876
Lowest temperature recorded.	Minus 5°	Minus 12°	Minus 15°
Date,	10th, 1875	10th, 1875	10th, 1875
Average date of first "killing" frost,	October 28th	October 21st	October 15th
Average precipitation (inches),	3.40	3.18	3.45
Average number of days with .01 inch or more,	12	16	20
Greatest monthly precipitation,	5.84	6.17	6.20
Date,	1873	1888	1878
Least monthly precipitation,	1.49	1.54	1.41
Date,	1872	1879	1875
Greatest amount in 24 hours,	2.24	2.34	1.62
Date,	5th, 1873	8th, 1884	27th and 28th, 1889
Greatest amount snowfall in 24 hours,	10.00	16.50	9.00
Date,	5th and 6th, 1893	8th, 1884	8th and 9th, 1886
Average number clear days,	7	4	2
Partly cloudy,	12	10	10
Cloudy,	12	17	19
Prevailing direction of wind,	NW.	W.	SW.
Highest velocity, miles per hour,	52	36	56
Date,	31st, 1878; 17th, 1885	26th, 1889; 21st, 1888	9th, 1876

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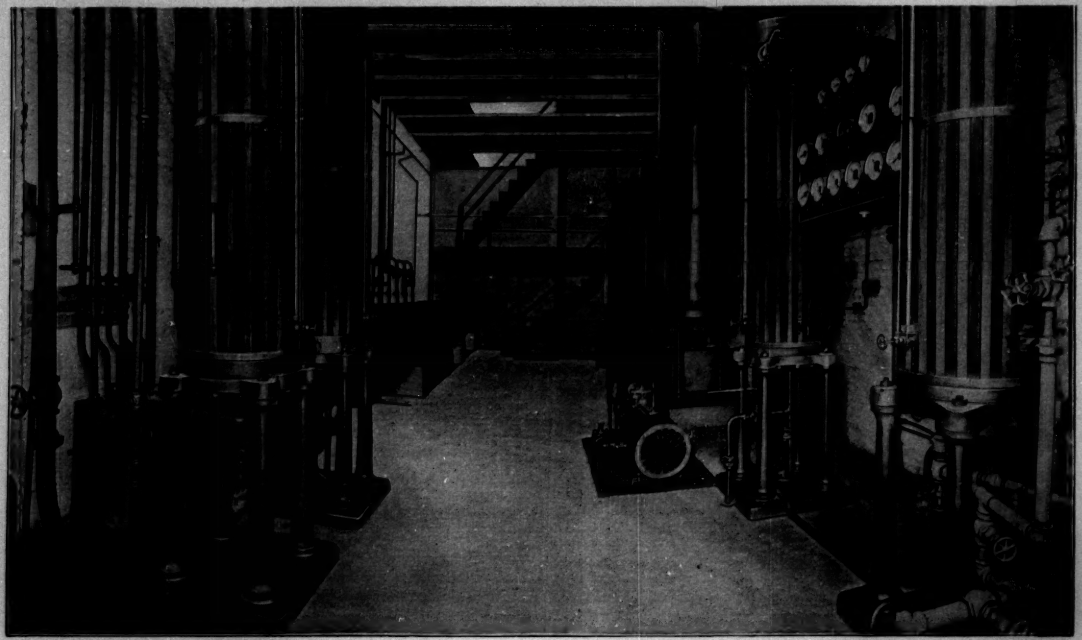

INTERIOR VIEW OF POWER HOUSE, COLORADO AUTOMATIC REFRIGERATING COMPANY, DENVER, COL., 1889.